WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Skokomish River Basin Fecal Coliform Bacteria Total Maximum Daily Load Study

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Skokomish River Basin Fecal Coliform Bacteria Total Maximum Daily Load Study

by
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List of Acronyms

AMV	arithmetic mean value
BMP	best management practices
BOD	biological oxygen demand
cfs	cubic feet per second
CI	confidence interval
CV	coefficient of variation
DO	dissolved oxygen
DOH	Washington State Department of Health
EC	*Escherichia coli (E. coli)*
Ecology	Washington State Department of Ecology
EMTS	Environmental Monitoring and Trends Section
EPA	U.S. Environmental Protection Agency
FC	fecal coliform bacteria
FCmf	fecal coliform by membrane filter
FCmpn	fecal coliform by most probable number
GIS	geographic information system
GMV	geometric mean value
LA	load allocation
mg/L	milligrams per liter
mL	milliliters
ppt	parts per thousand
QAPP	quality assurance project plan
RM	river mile
RMSCV	root mean square of the coefficient of variation
RPD	relative percent difference
RSD	relative standard deviation
STR	Statistical Theory of Rollback
TMDL	Total Maximum Daily Load
Tribe	Skokomish Indian Tribe
TSS	total suspended solids
USGS	U.S. Geological Survey
WAC	Washington Administrative Code

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Abstract

A Total Maximum Daily Load (TMDL) study for fecal coliform bacteria (FC) was conducted for the Skokomish River, because FC levels were not meeting fresh water quality standards due to nonpoint source pollution. The goal of the TMDL is to protect public health from pathogens in fresh water and help protect the marine waters of Hood Canal and shellfish harvesting in Annas Bay. The study was a cooperative effort with the Skokomish Tribe, whose Reservation includes part of the watershed. This study precedes the development of a water cleanup plan which will guide activities to better manage FC pollution.

The Department of Ecology sampled 18 stream sites from January 1999 through January 2000, seven of which were sampled concurrently by the Skokomish Tribe. Study results confirmed violations of water quality standards for FC and found seven sites where dissolved oxygen did not meet standards. The mean daily FC load was calculated for each site using a 10-month averaging period. Load balances indicate the presence of significant FC sources (52% of the FC load) along the lower mainstem corridors of the Skokomish River and Purdy Creek between the bridges for Highways 106 and 101, and East Bourgault Road. Weaver Creek and Hunter Creek contributed the next largest loads (14% and 9%, respectively).

Most streams in the lower Skokomish River basin must have FC levels well below Class AA fresh water criteria in order for marine waters and their beneficial uses to be protected. FC load allocations for mainstem and tributary sites are recommended, and these allocations are translated into FC concentrations that will be allow water quality standards to be met.

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Introduction

Background

Section 303(d) of the federal Clean Water Act requires the Washington State Department of Ecology (Ecology) and the U.S. Environmental Protection Agency (EPA) to establish the Total Maximum Daily Load (TMDL) of each pollutant that causes a waterbody to not meet water quality standards. The Skokomish River Fecal Coliform TMDL is being established to (1) address water quality impairments due to high fecal coliform bacteria (FC) levels in the lower Skokomish River basin and (2) help protect marine water quality standards and shellfish harvesting in Hood Canal.

A TMDL includes problem identification, technical analysis to determine the load capacity for the listed pollutant, evaluation and allocation of pollutant loads for various sources, and development of an implementation plan (or water cleanup plan) informed by public participation. The TMDL must also consider seasonal variations and include a margin of safety that takes into account any lack of knowledge about the causes of the water quality problem or its loading capacity. All TMDLs must be approved by the EPA.

The TMDL applies to areas upstream of the Highway 106 bridge and includes part of the Skokomish Indian Reservation (Reservation) and areas under state jurisdiction. The EPA and the Skokomish Tribe (Tribe) have Clean Water Act jurisdiction on all lands within the Reservation.

Varied activities have increased the level concern about FC pollution in the lower Skokomish River basin. In 1996, Ecology's long-term monitoring program determined that FC levels in the river at the Highway 101 bridge were not meeting water quality standards. For most years since 1995, the Washington State Department of Health (DOH) has listed the Annas Bay commercial shellfish harvest areas as threatened due to FC contamination (Melvin, 2000). Water quality monitoring conducted by the Tribe from 1995 through 1997 identified high FC levels in mainstem and tributary areas of the watershed (Skokomish Tribe, 1987). In 1998, the Water Quality section of Ecology's Southwest Regional Office identified the lower Skokomish River watershed as a high priority for a TMDL technical study of FC (Barreca, 1998). The Mason County Conservation District anticipated the need for landowners to manage their impacts on water quality and fish habitat, and was awarded a Centennial Clean Water Fund grant in 1998 to help landowners fulfill these needs (Ecology, 1998).

The technical study began in 1999 with the development of the Quality Assurance Project Plan (Hoyle-Dodson and Pickett, 1999). This 2001 technical report will be used by state and Tribal governments, as well as local citizens, to develop a water cleanup plan for the management of bacterial nonpoint source pollution in the lower Skokomish River. This TMDL report and the water cleanup plan will be submitted to the EPA for approval in accordance with Section 303(d) of the Clean Water Act. The Tribe and EPA will use information from this technical report to support their actions to achieve FC reductions within the Reservation. Funding for this technical study was provided through an EPA grant to Ecology.

Many organizations have interests in the water quality of the Skokomish River basin. Jurisdictions within the basin include the Tribe, Ecology, DOH, Mason County, U.S. Forest Service, and the U.S. Park Service:

- The Tribe manages lands and resources associated with their Reservation.
- Ecology is responsible for ensuring that the state's water quality standards are met.
- DOH monitors the quality of shellfish growing waters in Annas Bay according to federal guidelines for the protection of human health.
- The Mason County Environmental Health division has primary responsibility for on-site sewage systems.
- Forested areas in the upper watershed are managed by federal, state, and private landowners.
- The Mason County Conservation District works, on request, with local agricultural operations to help manage farm resources.

Problem Description

Since 1995, bacterial contamination of fresh and marine receiving waters has been documented as a water quality problem in the lower Skokomish River basin through ongoing monitoring efforts by Ecology, DOH, and the Tribe. Ecology listed 11 stream segments in the lower Skokomish River under Section 303(d) of the federal Clean Water Act in 1996 for not meeting water quality standards for FC (Table 1). Ecology also listed eight of those streams in 1998. FC is an indicator of the presence of other pathogens (e.g., bacteria and viruses) associated with sewage or manure that can be harmful to humans. Nonpoint source pollution is the source of FC contamination as there are no point sources of FC or regulated stormwater discharges in the basin. Every year since 1995 (except 1999) DOH has listed the Annas Bay commercial shellfish harvest areas as threatened, due to FC contamination (Melvin, 2000). While there has not yet been shellfish harvest restrictions, there is growing concern that there will be in the future unless FC pollution is addressed.

The increasing frequency and intensity of flooding of the Skokomish River valley is also a recognized problem for many reasons, including water quality. The flooding problem is being addressed through a variety of other local, state, and federal mechanisms and is not the subject of this TMDL effort. While it is recognized that flood events can affect water quality, non-flood related problems of FC contamination require attention. This current water quality study was designed to characterize the FC problem throughout a one-year period, which included a wide range of hydrologic conditions.

Water Quality Standards

The fresh waters of the Skokomish River and the marine receiving waters of Hood Canal are classified as Class AA (extraordinary) in Chapter 173-201A of the Washington Administrative Code: Water Quality Standards for the Surface Waters of the State of Washington. Fresh water

Table 1. Skokomish River basin streams on the 1996 and 1998 303(d) lists for FC.

Stream Name	New Segment ID	1998 303(d) list	1996 303(d) list
Hunter Creek at Skokomish Valley Rd.	no ID	yes	yes
Purdy Creek at E. Bourgault Rd.	MJ89JI	yes	yes
Purdy Creek at mouth	MJ89JI	yes	yes
Skokomish River at Hwy. 101	WW06HB	yes	yes
Skokomish River at Hwy. 106	WW06HB	yes	yes
Skokomish River near mouth (@ Bobby Allens)	WW06HB	yes	yes
TenAcre Creek at Campbell Ln.	no ID	yes	yes
Weaver Creek at Skokomish Valley Rd.	no ID	yes	yes
Skokomish River at Rocky Beach	WW06HB	no	yes
Skokomish River at Chico's Eddy	WW06HB	no	yes
Weaver Creek at E. Bourgault Rd.	no ID	no	yes

standards apply to the entire Skokomish River basin where salinity is less than 10 parts per thousand (WAC 173-201A-060) and marine water standards apply where salinity is 10 parts per thousand or higher:

- *Fresh water – fecal coliform organism levels shall both not exceed a geometric mean value of 50 colonies/100 ml, and not have more than 10 percent of all samples obtained for calculating the geometric mean value exceeding 100 colonies/100 mL.*

- *Marine water – fecal coliform organism levels shall both not exceed a geometric mean of 14 colonies/100 ml, and not have more than 10 percent of all samples obtained for calculating the geometric mean value exceeding 43 colonies/100 mL.*

Dissolved oxygen in fresh waters was also evaluated during this current study. Fresh water Class AA standards apply:

- *Fresh water – dissolved oxygen shall exceed 9.5 mg/L (*milligrams per liter).

Other groups invested in water quality may use standards that are slightly different from those above. For evaluating the quality of water for shellfish harvest, DOH criteria are similar, but are not bound to the 10 ppt salinity threshold since federal guidelines are used as part of the National Shellfish Sanitation Program. The Skokomish Tribe is in the process of developing water quality standards that will be applicable within Tribal lands. This TMDL may need to be re-evaluated in the context of Tribal water quality standards once they are adopted.

Study Area

The Skokomish River drains a basin of about 247 square miles and discharges to Annas Bay in southern Hood Canal near Potlatch, Washington (Figure 1). Major sub-basins include the North Fork Skokomish River (118 square miles), South Fork Skokomish River (104 square miles), and Vance Creek (25 square miles). The lower 10 miles of the river pass through a broad floodplain which is the primary area of residential and agricultural land use in the basin. The lower Skokomish Valley has several streams crossing it, the largest of which are Purdy Creek, Weaver Creek, and Hunter Creek. Molenaar and Noble (1970) describe groundwater occurrence, aquifers, and the sub-surface geology of the lower valley in more detail. The streams and springs in the valley contribute to several large wetland areas which then drain to the mainstem of the Skokomish River mostly downstream of Highway 101 at river mile (RM) 5.3. The river then discharges to the tidal estuary of Annas Bay and Hood Canal. Tidal influence on river water levels extends up to about RM 3.9, about 1.8 miles upstream of the Highway 106 bridge. The upper extent of saltwater presence in the river is not known and is probably downstream of RM 3.9.

Rainfall levels in the basin range widely, from 75 inches per year near the mouth to 230 inches per year at the crest of the Olympic Mountains near 6,000 ft. elevation (Phillips, 1968). Much of the winter precipitation in the mountains accumulates as snowpack which then provides runoff in the North and South Forks through the spring and early summer months. The dry season runs from July into September, followed by an October through March wet season in which more than 75% of the annual precipitation occurs. Weather systems moving across the basin during the wet season commonly alternate between cold and warm fronts. Snow deposited during cold fronts is commonly melted during the passage of rainy warm fronts, thus increasing runoff and contributing to valley flooding (KCM, 1997). Numerous studies of this chronic flooding problem have been done since the 1940s and are summarized in the recent Mason County Skokomish River Comprehensive Flood Hazard Management Plan (KCM, 1997).

Human activities have altered the natural hydrologic regime in the entire Skokomish basin. Forestry, road building, dikes, levies, and other land use practices have caused an unnatural filling of the lower river channel with aggregate to over five times background levels. The effect has been an increase in the frequency and intensity of flood events, higher basin groundwater levels, and subsequent septic system failures (Barreca, 1998). The operation of the Cushman Dam for power generation diverts about 90% of the North Fork's flow to Potlatch on Hood Canal (KCM, 1997).

The lower part of the Skokomish Valley has several streams, fed by springs on the southern valley wall, which meander though the valley and eventually discharge to the Skokomish River. Substantial wetlands are associated with these streams, particularly TenAcre, Weaver, Purdy, Ikes, and Rods creeks. The courses of these streams appear to have changed over the years due to flood activity, wetland dynamics, and human management.

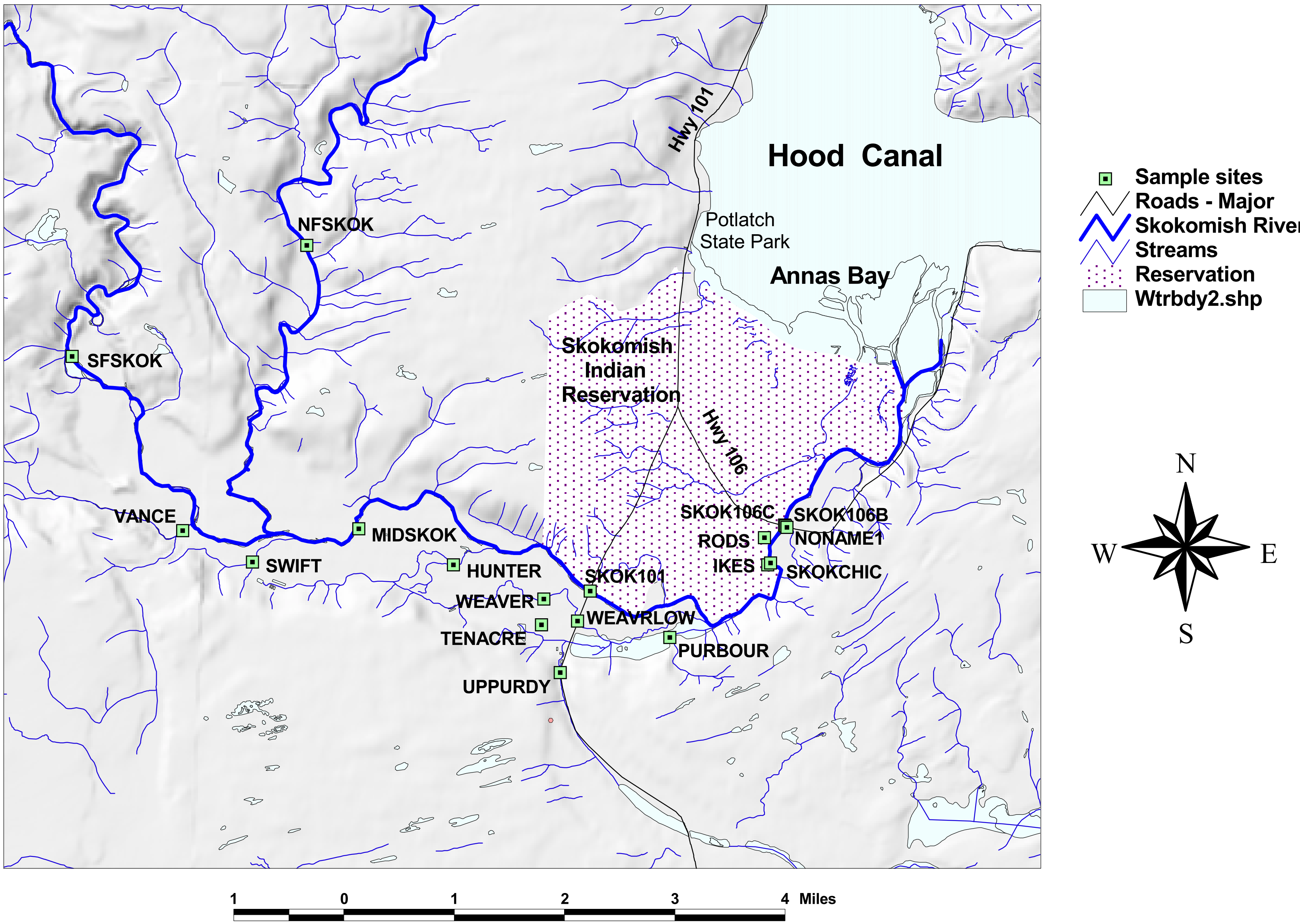

Figure 1. Skokomish River bacteria TMDL study area.

Land Use

The Skokomish River basin is sparsely populated and rural. The Skokomish Indian Reservation is located at the mouth of the basin and contains low-density residential development. Commercial and noncommercial agricultural activities occur in the lower river valley and include cattle and other livestock culture, hay and Christmas tree production, and some vegetable cropping. Silviculture within U.S. Forest Service and privately-owned lands dominate the upper basins. The upper reaches of the Skokomish River lie within the Olympic National Park. The North Fork basin includes Lake Cushman, a reservoir maintained for hydroelectric power generation whose shores include residential development.

The varied resources of the lower Skokomish River area are shared by many groups. The Annas Bay estuary contains a rich shellfish resource that is used by Tribal, commercial, and recreational harvesters. Recreational shellfish beds are located within, and to the south of, Potlatch State Park. Potlatch State Park is also a center of primary contact recreation, being used by swimmers and scuba divers. The mainstem Skokomish River and lower Vance Creek are also used by swimmers and waders during the summer months. The Skokomish River valley provides important habitat to a variety of terrestrial wildlife such as elk, deer, beaver, and waterfowl. Wildlife, shellfish, and finfish are important cultural and economic resources for the Tribe.

The Skokomish River system provides valuable habitat for important species of fish such as chinook, coho, and chum salmon; steelhead; and various trout (Williams, 1975). Chinook salmon and summer chum in this basin are listed as "threatened" species under the Endangered Species Act. Bull trout reside in the South and North forks of the Skokomish River and are listed as threatened.

Three fish-rearing facilities comprise the only point sources of pollution in the study area. The first of these facilities was built in the 1940s, and all are located along the southern valley wall where nearby springs provide ideal supply water for fish-rearing operations. Pollutant discharges from these facilities are managed under the Upland Fin-Fish Hatching and Rearing National Pollutant Discharge Elimination System Waste Discharge General Permit. Pollutants monitored under this permit generally relate to settleable and suspended solids; FC is not included since it has been documented that such operations are not a source of FC (Kendra, 1988).

Pollutant Sources

Sources of FC in the project area includes humans, domestic animals, and wild animals. Residential areas associated with Lake Cushman are unlikely to be a source of FC to the study area. Low levels of FC were found in the North Fork of the Skokomish River downstream of Lake Cushman during this study. The September field surveys noted significant amounts of human feces and trash along the right bank of the river near the Highway 106 bridge; these observations coincided with the fall fishing season when many anglers use the river. The domestic livestock population in the lower valley is estimated to include about 900 cattle, 40 horses, and a smaller number of llamas, goats, and chickens. Most of the domestic livestock are located on properties that do not have a farm management plan: there are only three farms in the valley that have a current farm plan (Mason County Conservation District, 2000). Estimates of wildlife populations, such as elk, deer, beaver, and waterfowl, were not obtained.

Project Objectives

The goal of the overall TMDL project is to characterize FC pollution and develop a plan to reduce this pollution in order to protect beneficial uses. This current technical study focused on characterizing FC pollution in the study area. The development of an implementation plan will be the next step of the TMDL process. Objectives of the technical study were to:

- Characterize FC concentrations and loads in the lower Skokomish River and tributaries.
- Estimate the loading capacity of the waterbodies for FC.
- Consider the impact of bacteria loading to the marine waters of Hood Canal and, if necessary, develop load allocations that would be protective of marine water quality standards and the shellfish harvest resource.
- Develop load allocations and target reductions necessary for the waterbodies to meet applicable fresh water standards for FC.
- Compare water quality data collected by Ecology and the Skokomish Tribe, and determine if historical tribal data can be used in developing the TMDL.

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Water Quality Data

Methods

The Quality Assurance Project Plan (Hoyle-Dodson and Pickett, 1999) for this study describes procedures that were followed for the collection and analysis of laboratory samples and for measurements made in the field. Sample site locations are shown in Figure 1 and described in Table 2. Monitored parameters and methods are presented in Table 3. The study excluded areas downstream of the Highway 106 bridge and the shoreline areas of Annas Bay.

Monitoring surveys occurred once per month for most sites from January 1999 through January 2000. The sites on Swift Creek, Weaver Creek at West Bourgault Road, Ikes Creek, Rods Creek, and the Skokomish River at the center of the Highway 106 bridge were sampled from September 1999 to January 2000 only. Several sites were sampled twice per month from November 1999 to January 2000 to provide more information about wet-season levels of FC. These sites were Vance Creek, Hunter Creek, Weaver Creek at West Bourgault Road, Purdy Creek at East Bourgault Road, and the Skokomish River at the center of the Highway 106 bridge. These additional surveys had FC samples analyzed with the membrane filter technique (referred to as "FCmf" in this report). All other FC samples during the survey were analyzed with the multiple tube fermentation technique (referred to as "FC" in this report).

Additional bacteria data were collected and examined during this study. Concentrations of *Escherichia coli* were determined at most sample sites because Ecology was considering adopting *E. coli* as a bacteria standard when the project plan was developed. Also examined were FCmf data from Ecology's ambient monitoring station (Station No. 16A070, Skokomish River at the Highway 101 bridge). Comparability of the multiple tube fermentation technique with the membrane filter technique, as well as comparability of FC to *E.coli*, are discussed in Appendix A. The Tribe collected samples concurrently with Ecology at seven sites on the monthly schedule in order to evaluate the comparability of Ecology and Tribal FC data.

Field sampling and measurement protocols followed procedures in Ecology (1993). Field instruments used to collect conductivity and temperature data were an Orion 135® Conductivity meter and a Hydrolab Surveyor 4®. Instruments were calibrated according to manufacturers' instructions. Dissolved oxygen was determined using the Winkler titration method at Ecology's headquarters laboratory in Olympia, Washington.

Samples were taken as surface grab samples directly into sample bottles. At bridges, sample containers were lowered in a customized carrier attached to a rope. At banks, an extendable pole with clamp was used to collect the sample. Field and laboratory duplicate procedures are discussed in Appendix A.

Samples were tagged, and placed on ice in the dark and transported to Ecology's headquarters in Olympia. Samples were delivered to Ecology's Manchester Laboratory the next day so that analysis could begin within approximately 24 hours of collection. FC samples collected by the

Table 2. Sampling sites for the Skokomish River TMDL water quality study, 1999-2000.

Site Name	Site Description	Latitude North	Longitude West
SFSkok	South Fork Skokomish, 3 diff. sites downstream of USGS gage: RM 3.1, RM 2.7,	47.338273	123.276958
NFSkok	North Fork Skokomish, at old log road wet crossing, RM 12.5	47.353890	123.232333
MidSkok	Skokomish mainstem, right bank at Church Dike along W Skokomish Valley Rd, RM	47.317164	123.221303
Skok101	Skokomish mainstem, center of Hwy 101 bridge, RM 5.3	47.310122	123.175569
SkokChic	Skokomish mainstem, left bank at Chico's Eddy, RM 2.5	47.314438	123.140808
Skok106b	Skokomish mainstem, right bank at Hwy 106 bridge, RM 2.1	47.319550	123.138164
Skok106c	Skokomish mainstem, center of Hwy 106 bridge, RM 2.1	47.319608	123.138539
Vance	Vance Creek, at W Skokomish Valley Rd bridge	47.315392	123.255697
Swift	Swift Creek (aka Vance Creek on USGS map), at W Skokomish Valley Rd bridge	47.312172	123.240751
Hunter	Hunter Creek, at W Skokomish Valley Rd bridge	47.313053	123.202667
UpPurdy	Purdy Creek, at upstream of all hatchery intake structures	47.299126	123.180754
TenAcre	TenAcre Creek, at culvert under side road off of W Skokomish Valley Rd	47.305131	123.184417
Weaver	Weaver Creek, at W Skokomish Valley Rd bridge	47.308881	123.184350
WeavrLow	Weaver Creek, at W Bourgault Rd bridge	47.305976	123.177734
PurBour	Purdy Creek, at bridge on E Bourgault Rd	47.304238	123.159728
Ikes	Ikes Creek, small creek draining wetlands, at bridge on Skokomish River Rd	47.314232	123.141589
Rods	Rods Creek, small creek draining wetlands, at bridge on Skokomish River Rd	47.317097	123.141736
NoName1	Between Skokchic and Skok106b	47.319336	123.137972

Latitude and longitude coordinates based on NAD 1927

Table 3. Summary of field and laboratory methods.

Field Analyses	Accuracy	Method [1]
Stream Velocity	± 0.2 feet/second	March McBirney or Swoffer velocity meter
Temperature	± 0.1 °C	alcohol thermometer or thermistor
Dissolved Oxygen	± 0.1 mg/L	Winkler, APHA SM 15th ed., 421B
Dissolved Oxygen	± 0.1 mg/L	Electrode, APHA SM 16th ed., 421F
Specific Conductivity	± 5 µmho/cm	APHA SM 18th ed., 2510B

Laboratory Analyses	Reporting Limit	Method
Specific Conductivity	1 µmho/cm	EPA 120.1
Total Suspended Solids	1 mg/L	EPA 160.2
Fecal Coliform, membrane filter	1 FC/100mL	APHA SM 16th ed., 909C
Fecal Coliform, most probable number	1 FC/100mL	APHA SM 16th ed., 908C
Escherichia coli, most probable number	1 FC/100mL	EPA 1104

[1] APHA; 1981, 1985, and 1992
[1] USEPA, 1983.

Tribe were stored and transported by employees of the Tribal Natural Resources Office and analyzed at the Thurston County Public Health Department Laboratory on the day of sample collection.

Streamflows were determined using a variety of techniques such as in-situ measurements, or rating curve estimates or flow balance calculations. Measurements and estimates generally followed procedures described by Ecology (Ecology, 1992). Flow data for the South Fork Skokomish River, North Fork Skokomish River, and the Skokomish River at Highway 101 were obtained from the U.S. Geological Survey (USGS) at *http://wwwdwatcm.wr.usgs.gov.* Appendix B describes flow estimation techniques in detail. Precipitation data for the area were obtained from the U.S. Forest Service Hoodsport Ranger District office in Hoodsport, Washington. Climate data were also obtained from the National Climate Data Center.

Field and lab data were compiled and organized using Excel® spreadsheet software as the primary tool. Water quality results from field and laboratory work were also entered into Ecology's developing Environmental Information Management database. Statistical calculations were made using either Excel® or SYSTAT® (SPSS, 1997). ArcView® geographic information system (GIS) software was used to develop maps of the study area and display features of interest. GIS data layers were obtained through Ecology's GIS library.

For the TMDL analyses, water quality data from several sites were amended in order to simplify loading estimates and reduce possible bias due to seasonal or sample location factors. Several sites were sampled late in the study only, from September to January, so had missing FC values for the earlier part of the study period. These were Swift Creek, Ikes Creek, Rods Creek, NoName1 Creek, Skokomish River at the center of the Highway 106 bridge, and Weaver Creek at West Bourgault Road. The arithmetic mean value (AMV) for these sites was used as the estimated FC value for the months of the study period when no samples were taken; the AMV for the averaging period was then recalculated with these data.

The samples collected from the center of the Highway 106 bridge (site Skok106c) were also used to evaluate the representativeness of the bank samples (Appendix A). Earlier samples from the Skokomish River at Highway 106 were collected on the right bank, just under the bridge (Skok106b). The AMV of the paired bank and bridge results were used in calculating the study-period FC AMV in the Skokomish River at Highway 106 (Skok106). This AMV was used in subsequent TMDL analyses. Summary statistics (GMV and 90th percentile) for these and other sites are discussed later in this report.

Quality Assurance and Quality Control Results

Appendix A discusses quality assurance procedures and results for precision, completeness, representativeness, and comparability of the data. Water quality data met data quality objectives in most cases. Streamflow data were incomplete, necessitating the use of various estimation techniques. Lack of adequate streamflow data prevented more accurate estimates of FC loading at study sites. Data not meeting quality objectives were noted and their quality considered for use in the TMDL analyses. Nearly all data were used, and FC values qualified as estimates or as undetected at the reporting limit were used as reported.

Water Quality Monitoring Results

Ecology study data collected for the study period, January 1999 through January 2000, are contained in Appendices C1 and C2. Tribal data are contained in Appendix C3. Ecology data are summarized here with boxplots (Figure 2). Each boxplot is a graphical summary of the distribution of data collected at each site. The box defines the inter-quartile range (25th to 75th percentile) with the centerline indicating the median (50th percentile). The upper and lower whiskers indicate the range of values lying within 1.5 times the inter-quartile range. Asterisks indicate values lying between 1.5 and 3 times the inter-quartile range (SPSS, 1997). Horizontal dashed lines in the plots for FC, DO, and temperature indicate the water quality criterion for that parameter. The plot for FC includes an "X" denoting the 90th percentile. Plots for the flow data in Figure 2 are based on flow estimates described in Appendix B. The flow values for several sites (mid-Skokomish River near the Church Dike, Skokomish River at Chico's Eddy, and the Skokomish River at the center and right bank of the Highway 106 bridge) were derived from summing upstream flows.

The mainstem Skokomish River upstream of the Highway 101 bridge displays relatively low FC levels. Bacteria levels rise markedly downstream of the Skokomish River at the Highway 101 bridge, likely due to pollutant sources along the mainstem and/or discharge of the Purdy Creek system into the river. Sites on Vance, Swift, and upper Purdy creeks had low FC while sites on Weaver, lower Weaver, and Purdy creeks at West Bourgault Road showed the highest FC levels.

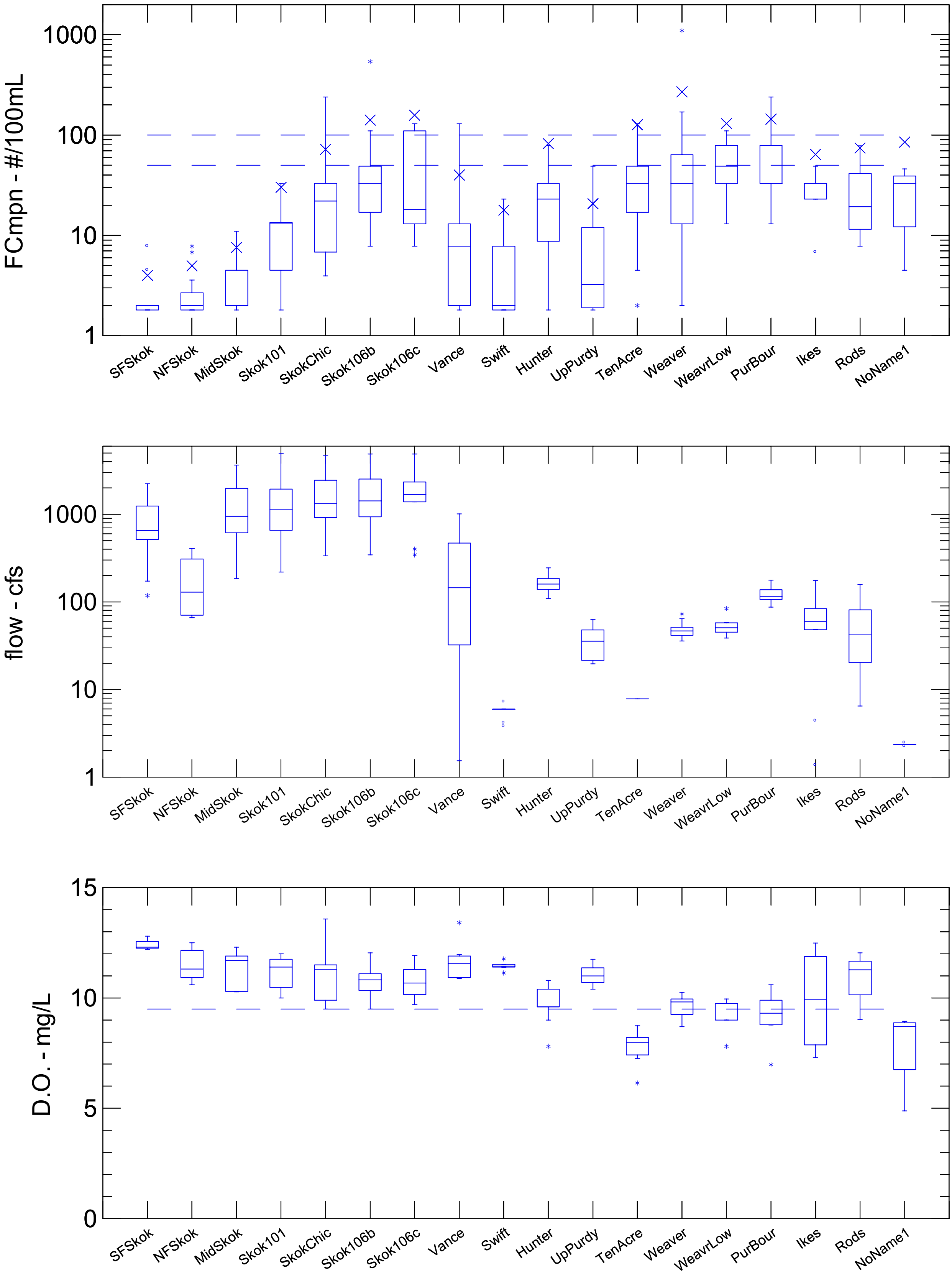

Figure 2a. Water quality data summary plots.

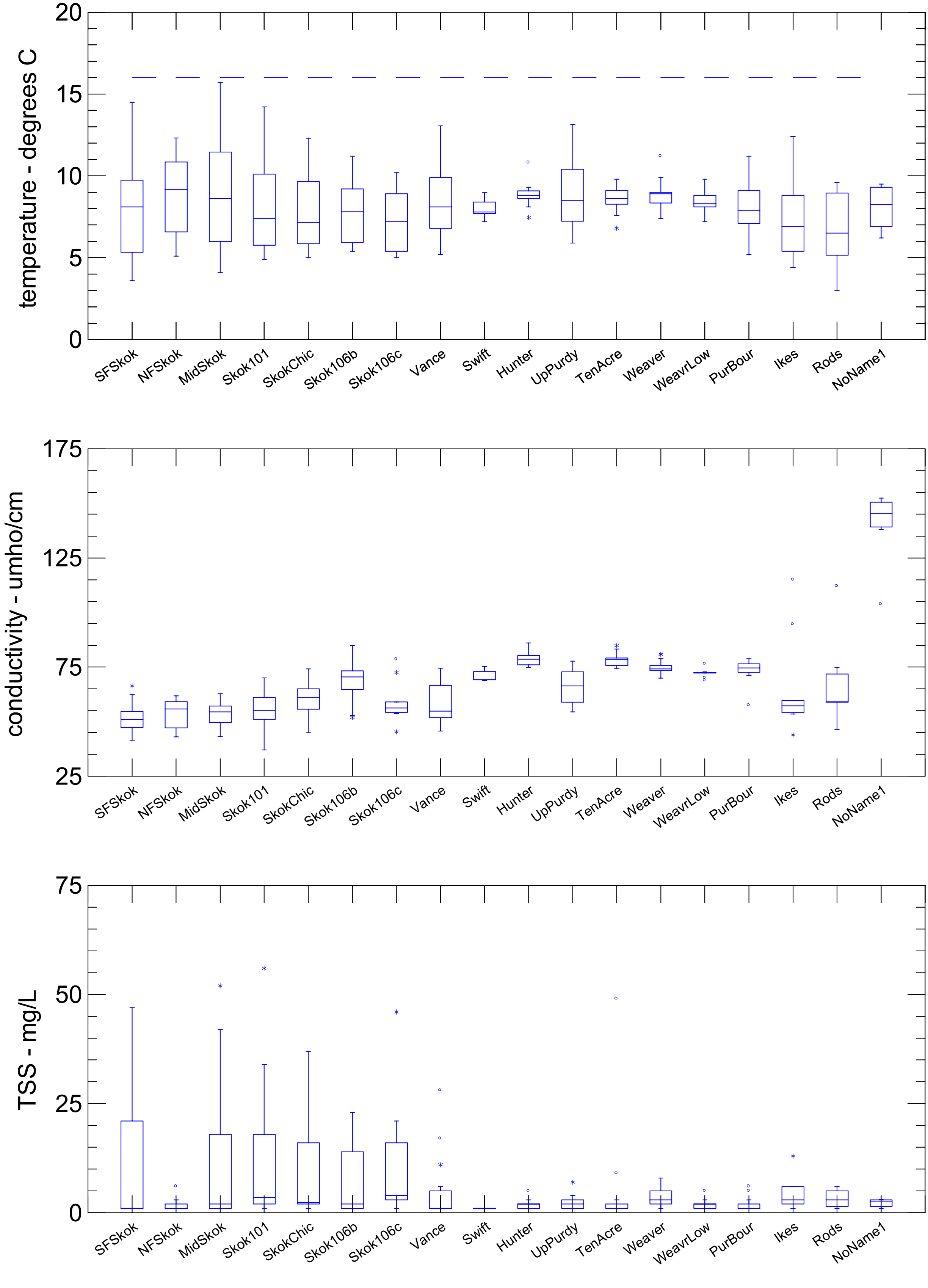

Figure 2b. Water quality data summary plots.

The historical record of FCmf at the Skokomish River at Highway 101 is shown in Figure 3. Although this figure shows an apparent increase in FCmf over time, it is not statistically significant. Further discussion of FC results occurs later in this report.

Dissolved oxygen (DO) levels in most of the tributary sites did not meet Class AA water quality standards (minimum of 9.5 mg/L per WAC 173-201A-030). Figure 2 indicates the sites where DO values were less than the water quality standard. Table 4 summarizes DO data for sites that did not meet standards. Violations of water quality criteria occurred throughout the year as did lower saturation values, suggesting causes other than temperature for low DO. Determining the reasons for depressed DO was beyond the scope of this study and would require additional work. Possible causes of depressed DO include a large groundwater input that is low in DO, wetland areas exerting a biological oxygen demand (BOD) from decay of organic material, and loading of organic material or nutrients to streams from human activities such as agricultural and fish hatchery operations.

Table 4. Study sites not meeting the dissolved oxygen standard of 9.5 mg/L.

Station	No. violations / No. measurements	Range (mg/L)	Saturation range
Hunter	2/9	7.8 - 10.8	68% - 96%
TenAcre	13/13	6.2 - 8.7	53% - 74%
Weaver	4/10	8.7 – 10.3	74% - 90%
WeavrLow	2/5	7.8 – 10.0	67% - 88%
PurBour	6/11	7.0 – 10.6	60% - 89%
Ikes	2/5	7.3 – 12.5	68% - 96%
Rods	1/4	9.0 – 12.0	78% - 94%
NoName1	4/4	4.9 – 8.9	43% - 78%

Characteristics of other parameters are shown in Figure 2b. Temperature values for the groundwater-dominated streams (Swift, Hunter, TenAcre, and Weaver creeks) were less variable throughout the year than values for the mainstem river and larger wetland sites. No violations of the water quality standards for temperature were found. Values for specific conductivity were generally low for the mainstem and upper tributaries, whereas the lower valley tributaries showed slightly higher values. The higher values in the lower tributaries are suggestive of their groundwater source. The Skokomish River mainstem and upper tributary sites exhibited consistently higher total suspended solids (TSS) concentrations than the lower valley tributaries, most likely due to their steeper gradients and more turbulent flow than the lower valley streams. All TSS concentrations were generally low.

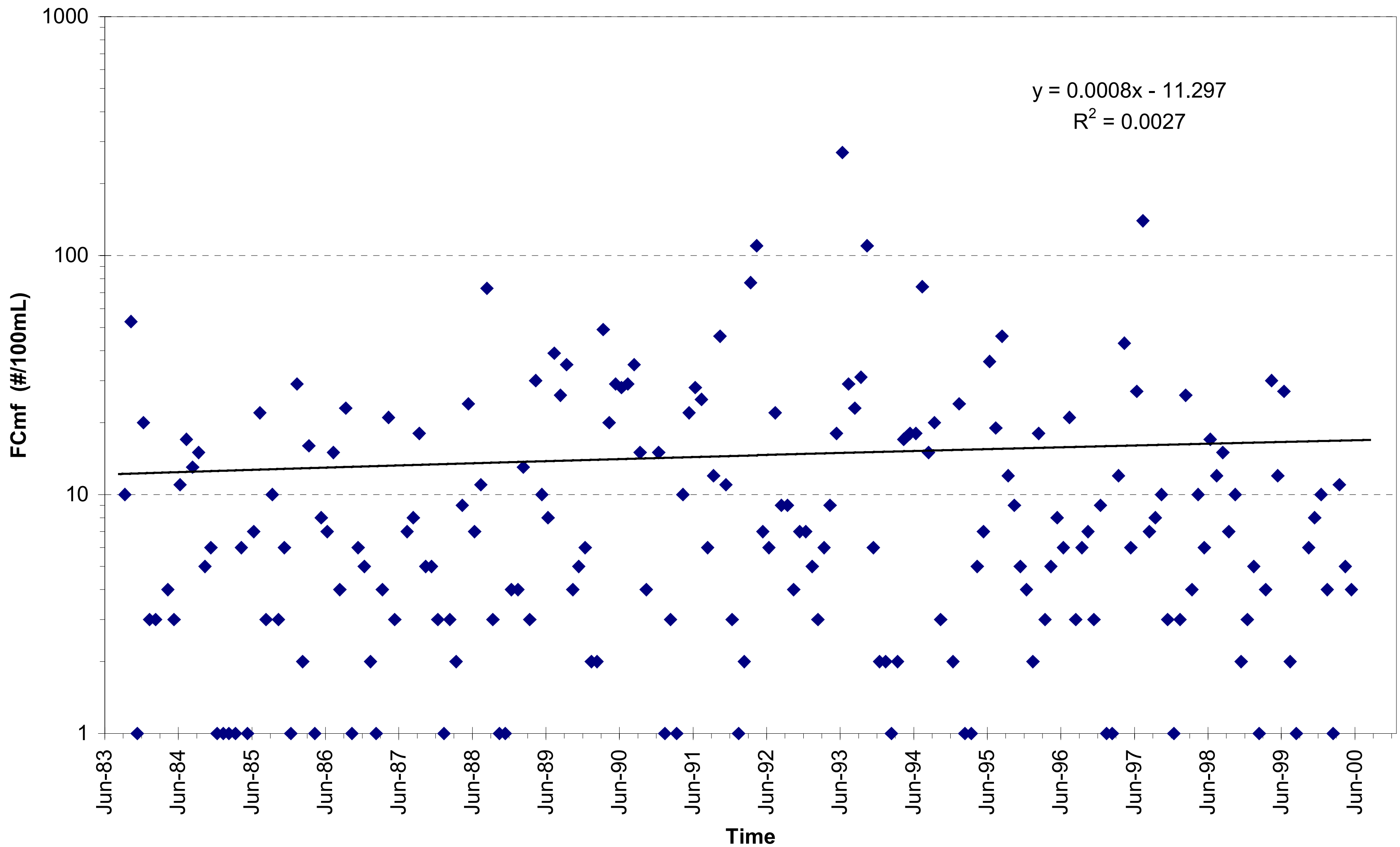

Figure 3. Historical FC levels in the Skokomish River at Highway 101.

The relationship of FC to streamflow and TSS was evaluated using scatterplots and regressions of these parameters for each site. Streamflow and FC were generally unrelated to each other which is consistent with the analysis in the Quality Assurance Project Plan. While significant relationships were absent, the streamflow and FC plots suggested that FC levels at most sites decrease slightly as flow increases. Relationships between FC and TSS were also generally absent.

One objective of this study was to determine the comparability of water quality data collected concurrently by Ecology and the Tribe during this study. Sample collection and laboratory methods used by the Tribe were reviewed and deemed comparable to Ecology methods. Tribal and Ecology FC results were also deemed comparable (Appendix A). Ecology chose not to use the historical Tribal data for developing the TMDL since streamflow and other necessary data needed for its use were missing. Ecology's review of the Tribe's sampling techniques was forwarded to the Tribe's Natural Resources Office. Several recommendations for improving data management and reporting were made, and improvements in sample collection techniques took place during the course of the study.

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Fecal Coliform TMDL Analysis

Approach

The following summarizes the approach used in determining the TMDL for FC in the Skokomish River. Each is further discussed in this report.

- Evaluate seasonality and determine critical conditions and/or critical time period.
- Perform a flow balance.
- Develop the modeling approach for determining the TMDL and load allocations.
- Determine the TMDL and load allocations for protection of water quality standards.
- Characterize factors in the analyses that create a Margin of Safety for the TMDL.

All FC and FCmf data were examined for use in TMDL analyses. The FC data were selected for TMDL development for several reasons: (1) FC data will be comparable with historical and future data collected by the Tribe since the Tribe also uses the FC method, (2) FC data have a relative high bias compared to FCmf data, thus being more protective of beneficial uses, and (3) FC data are more comparable with Annas Bay FC data collected by DOH.

The downstream boundary defined in this study was the Skokomish River at the Highway 106 bridge; logistical challenges associated with sampling farther downstream prevented the study from including those areas. When considering the protection of marine standards, areas downstream of the Highway 106 bridge were assumed to have no sources of FC loading. This is a tenuous assumption, because residential and agricultural activities are present downstream of the Highway 106 bridge, and their influence on water quality in Annas Bay is not known.

Seasonal Variation and Critical Conditions

Seasonal patterns in all FC data were explored using various approaches. These approaches involved reviewing plots of FC concentrations at all sites over time, evaluating water quality standards compliance with data from various time periods, and examining FC loads to Annas Bay. The purpose was to find the largest data set (for statistical power) that did not mask periods of noncompliance with the water quality standards.

Various sets of FC data were examined for seasonality by plotting the data by month. The data suggested a pattern where March and April have the lowest FC levels of the year. Another pattern appears as increasing levels of FC from April through October. November through February showed variable FC levels with no consistent patterns.

Figure 4 shows monthly plots for several of the data sets examined and described below:

- Last ten years of Ecology EMTS Hwy 101 FCmf data by month. March had the lowest values.
- Five years of Tribal FC data from the mainstem Skokomish River sites. November, December, and March had the lowest values.
- The 1999-2000 TMDL study period using Ecology FC data from all study sites. April and March showed the lowest values.
- The 1999-2000 TMDL study period using Ecology FC data from the Purdy Creek basin sites (Weaver, Purdy, TenAcre, and upper Purdy creeks). April and March displayed the lowest values.
- The 1999-2000 TMDL study period using Ecology FC data from the mainstem river sites. April and March displayed the lowest values.
- Five years of Tribal FC data from all Tribal sites in the study area (Weaver, TenAcre, Purdy, Hunter, and Vance creeks, and Skokomish River at Highway 106). March had the lowest values, followed by April and May.
- Five years of Tribal FC data from Tribal tributary sites in the study area (Weaver, TenAcre, Purdy, Hunter, and Vance creeks). March had the lowest values, followed by April and May.
- The 1999-2000 TMDL study period using Ecology FC data from each study site were examined individually. March and April FC levels were frequently among the lowest values found at each site.

Various averaging periods were examined for sensitivity to violations of the water quality standards. The water quality standard is based on a geometric mean value (GMV) of the FC data collected. These data sets were attentive to the prohibition of using averaging periods that mask violations (WAC 173-201A-060(3)). The following multi-month averaging periods were evaluated:

- 5-month period (May through September: a drier period)
- 6-month period (May through October: a drier period)
- 7-month period (May through November: a dry then wet period)
- 7-month period (October through April: a wet period)
- 8-month period (May through December: a dry then wet period)
- 9-month period (May through January: a dry then wet period)
- 10-month period (May through February: a dry then wet period)
- entire 13-month study period (January 1999 through January 2000)
- rolling 3-month period. (This involved using data collected during months 1, 2, and 3 of 1999, then data for months 2, 3, and 4, then data for months 3, 4, and 5, and so on for the rest of the study period).

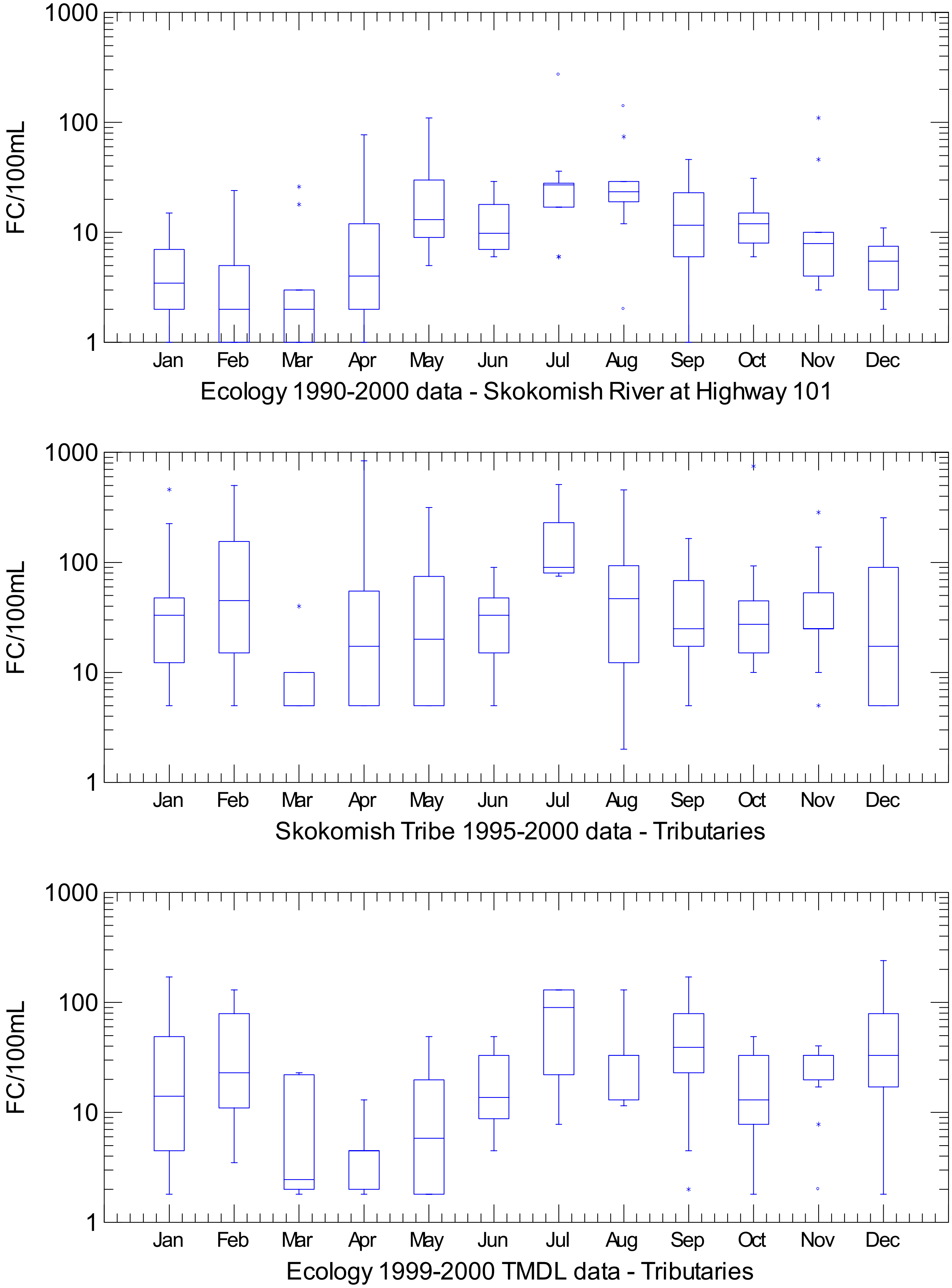

Figure 4. Monthly FC values from various data sets

FC loading to Annas Bay was examined using the Ecology TMDL study data from the Skokomish River at Highway 106. Slightly lower FC loads were observed in the summer months than in the winter months and were likely associated with lower flows.

The averaging period for the TMDL analyses was chosen to be the 10 months from May through February. This 10-month period remained as sensitive to water quality standards violations as did shorter averaging periods. This period covers most of the year while excluding the two months when bacteria concentrations were lowest. Seasonal patterns in FC concentrations or loads were deemed too weak to warrant development of TMDLs for separate seasons (e.g., wet season, dry season). Hence, this TMDL applies to the entire year. (The 10-month averaging period was used to develop the TMDL).

The historical record for flow and FC in the Skokomish River at Highway 101 compares favorably with flow and FC statistics from the 10-month averaging period. The USGS 55-year mean annual flow of the Skokomish River at Highway 101 is 1212 cfs. The mean annual flow estimated from the study period was 1419 cfs. This is about 17% higher than the historical mean, and remains within one standard deviation (245 cfs) of the historical mean. The ten-year historical record for FCmf in the Skokomish River at the Highway 101 bridge collected by Ecology yielded a GMV of 8.2 FC/100mL (n=23). The FCmf GMV for the 10-month averaging period was slightly lower at 4.8 FC/100mL (n=10). The FC GMV (mpn method) was 11.6 FC/100mL.

This study did not gather information about land use management practices and their potential seasonal effects on water quality. Such work was beyond the scope of this study and may be better addressed through a watershed planning effort. While seasonal patterns in FC data were not obvious, there may be seasonal factors associated with the presence and management of potential sources of FC, such as domestic livestock, on-site septic systems, waterfowl, terrestrial wildlife, and anglers. An increase of litter and human feces along the right bank of the river near the Highway 106 bridge was noted during the fall salmon sports fishing season. Many anglers were fishing from the riverbank or while wading.

Flow Balance

Flow balances were conducted for each survey during the averaging period for the Skokomish River at Highways 106 and 101, and Purdy Creek at East Bourgault Road. Flow values for all sites were developed as described in Appendix B. Mean daily flows were then determined for each site. The distribution of mean daily flow at sites in the study area is shown in Figure 5a. Nearly 85% of the flow that could be determined comes from four tributaries: South Fork Skokomish, North Fork Skokomish, Vance Creek, and Hunter Creek. The mean daily flow balances for the Skokomish River at Highways 106 and 101, and Purdy Creek at East Bourgault Road, are shown in Figures 5b, 5c, and 5d.

The flow balances for the Skokomish River at Highway 101, and Purdy Creek at East Bourgault Road, indicate additional flow contributions representing about 3% and 22%, respectively, of the flow at these sites. These residuals are the difference between the summed values and the

Figure 5a. Distribution of mean daily flow in the Skokomish River basin: 1999-2000 TMDL study.

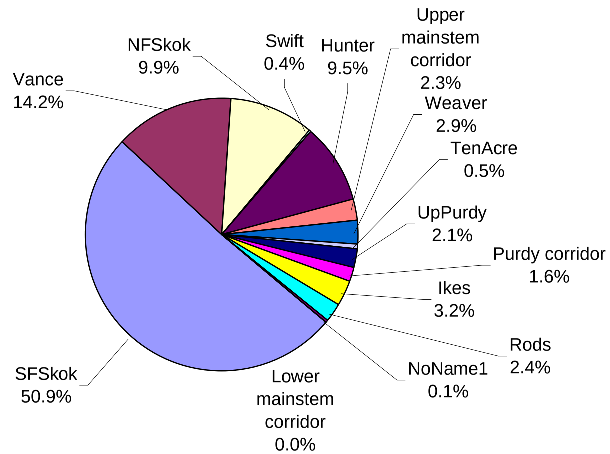

Figure 5c. Distribution of mean daily flow in the Skok101 sub-basin: 1999-2000 TMDL study.

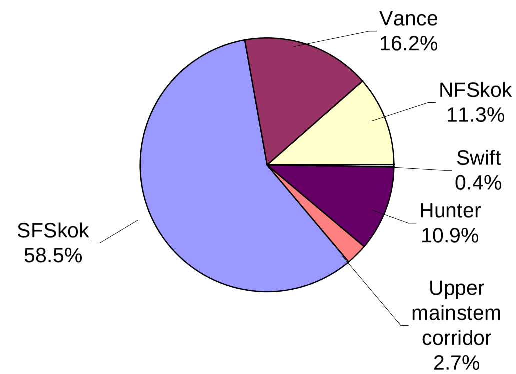

Figure 5b. Distribution of mean daily flow in the Skok106 sub-basin: 1999-2000 TMDL study.

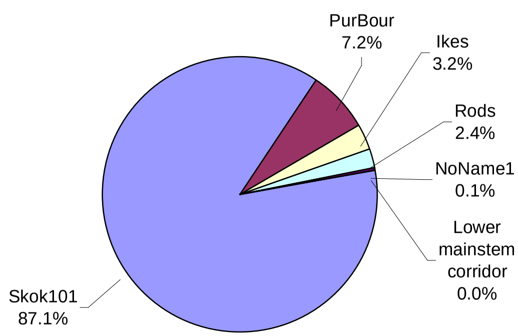

Figure 5d. Distribution of mean daily flow in the PurBour sub-basin: 1999-2000 TMDL study.

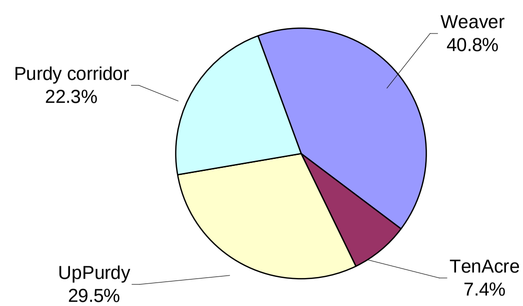

Figure 5. Distribution of mean daily flow in the Skokomish River basin.

observed value, and represent a combination of measurement error and contributions from surface water and/or groundwater.

Residual flows for the Skokomish River at Highway 106 could not be determined because flows were not measured at this site. Flow values for this site were derived from summing flow values from upstream sites. Although residual flows could not be determined for the Skokomish River at Highway 106, it is probable that unmeasured gains (or losses) in flow occur downstream of the Highway 101 and the East Bourgault Road bridges, resulting in flow values at the Highway 106 bridge that are different from summed values.

The residual flows play a role in contributing to residual FC loads (discussed in a following section). For descriptive purposes and later discussion, the area contributing flow (and FC) between the Skokomish River at Highway 101 and upstream sites (except site MidSkok) is called the "upper mainstem corridor" for the remainder of the report. Similarly, the area contributing flow (and FC) to the Skokomish River between Highway 106 and the bridges at Highway 101 and East Bourgault Road is called the "lower mainstem corridor". "Purdy corridor" refers to areas of the Purdy Creek basin between Purdy Creek at East Bourgault Road and the upstream sites (TenAcre, Weaver, and Upper Purdy creeks).

TMDL Development

The TMDL was developed such that FC levels in the Skokomish River and tributaries would meet fresh water quality standards and help protect marine water quality standards of the receiving waters. The Skokomish River mouth site, referred to be at "Bobby Allens" in the Tribe's 1997 report, was not monitored during this study. The site at the Highway 106 bridge was considered a more practical site for determining fresh water FC concentrations and loads. The approach used to determine the TMDL and load allocations were:

- Target levels of FC were determined for the Skokomish River at Highway 106 that would be protective of the water quality standards for the marine waters of Hood Canal.
- Target levels of FC were determined for fresh water sites such that fresh water sites would meet Class AA standards.
- The daily FC load was estimated for all sites for each survey during the averaging period. Mean daily load balances were calculated for the Skokomish River at Highways 101 and 106, and Purdy Creek at East Bourgault Road, using the arithmetic mean of the daily FC loads from contributing streams. These three sites segmented the study area conveniently and allowed a more detailed look regarding FC concentrations and loads at each of these areas.
- The load balance was evaluated to determine whether load reductions needed to meet fresh water standards were adequate for the Skokomish River at Highway 106 to be protective of marine standards.
- If necessary, reductions in mainstem corridor loads or additional tributary loads were made to ensure that FC levels at Skokomish River at Highway 106 would be protective of the marine standards.

Marine water uses protection

A target FC value for the Skokomish River at Highway 106 that would protect marine water quality standards in Annas Bay was determined by using fresh water and marine water FC and salinity data. The threshold was found where the marine FC water quality standard would be met in Annas Bay when the salinity was 10 parts per thousand (ppt). In estuarine waters, the marine water quality standard for FC applies when salinity exceeds 10 ppt (WAC 173-201A-060 (2)). In Hood Canal, the Class AA standard for bacteria is a GMV of 14/100mL, with not more than 10% of the samples used to determine the GMV exceeding 43/100mL.

The target FC GMV for the Skokomish River at Highway 106 was developed following the method described by Pickett (1997) for the Lower Skagit River TMDL Water Quality Study. This approach is based on average values of salinity found in the river and average background FC concentrations found in the receiving waters. A more sophisticated approach that incorporates changes over time in FC, salinity, river flow, tidal effects, temperature, and other variables was beyond the scope of this study.

Table 5 shows the derivation of FC target values for the Skokomish River at Highway 106. Background values for marine waters were obtained by using 1980-2000 data from Ecology's long-term monitoring program site HCB004 (Hood Canal off Sisters Point). The mean salinity for the three depths sampled (surface, 10, and 30 meters) at this site was 26.8 ppt; the GMV for surface-water FC was 1.3/100mL. The median conductivity of the Skokomish River at the center of the Highway 106 bridge was converted to a salinity value. When mixed to 10 ppt salinity, Annas Bay is composed of about 63% fresh water and 37% marine water. At these proportions of fresh water and marine water, a Skokomish River GMV of 21.5 FC/100mL, and 90^{th} percentile of 67.7 FC/100mL, would result in a FC GMV of 14/100mL and a 90^{th} percentile of 43/100mL when mixed with Hood Canal water to a salinity of 10 ppt. These values represent a 34% and 44% reduction in the GMV and 90^{th} percentile, respectively.

Since the distributional characteristics of environmental data from the same location tend to remain the same (Ott, 1995), the "rollback" technique was applied to develop the FC target values for this site. The rollback technique calls for the data set yielding the GMV and 90^{th} percentile to be reduced by the largest factor so that all data are scaled equally. Thus, the 44% reduction factor must also be applied to the GMV, which yields a target GMV of 18.5 FC/100mL. This target GMV of 18.5 FC/100mL corresponds to the target 90^{th} percentile of 67.7 FC/100mL. The "rollback" technique is further explained in the following section.

Fresh water uses protection

FC target values were determined for fresh water sites such that fresh water sites would meet Class AA standards. Targets were developed by applying the Statistical Theory of Rollback (STR) after Ott (1995). The STR, or "rollback“ method, was used in recent FC TMDL and load allocation analyses for the Nooksack River and Grays Harbor (Joy, 2000; Pelletier, 2000).

Table 5. Calculation of FC target values for the Skokomish River at Highway106 to protect marine water standards.

Marine water quality standards for FC (apply at 10 ppt salinity):	
GMV:	14 FC/100 mL
geometric 90th percentile:	43 FC/100 mL
Salinity of marine and fresh water before mixing:	
Hood Canal (HCB004):	26.80 ppt
Skokomish River at Hwy 106:	0.036 ppt
Percent fresh water in Annas Bay at 10 ppt salinity:	
	62.8 %
Hood Canal background FC GMV:	
Hood Canal (HCB004):	1.30 FC/100 mL
1st round FC target values @ Skok106 to protect Annas Bay:	
GMV	21.5 FC/100 mL
geometric 90th percentile:	67.7 FC/100 mL
1st round target values reduction from averaging period values:	
GMV	34 %
geometric 90th percentile:	44 %
2nd round FC target values @ Skok106 to protect Annas Bay:	
The 44% reduction factor must also be applied to the GMV to maintain distribution characteristics (see explanation of rollback method in text)	
GMV	18.5 FC/100 mL
geometric 90th percentile:	67.7 FC/100 mL

The rollback method uses statistical characteristics of a known data set to predict the statistical characteristics of a data set that would be collected after pollution controls have been implemented and maintained. In applying the rollback method, the target FC GMV and target 90^{th} percentile are set to the corresponding water quality standard. The reduction needed for each target value to be reached is determined. The reduction factor (e.g., percent reduction) that allows both target values to be met is selected and applied to the known GMV and the 90^{th} percentile. The result is a revised target value for the GMV or the 90^{th} percentile, depending upon which reduction factor was used. In most cases, a reduction of the 90^{th} percentile is needed and application of this reduction factor to the study GMV yields a target GMV that is usually less (i.e., more restrictive) than the water quality standard. The 90th percentile is used as an equivalent expression to the "no more than 10%" criterion found in the second part of the water quality standards for FC.

Table 6 summarizes statistical characteristics of FC from the averaging period and target values for those sites not meeting water quality standards. The data sets used for determining GMVs and 90th percentiles at sites were discussed in the Methods section.

Table 6. Summary statistics for FC during the averaging period and for target reductions.

Site	Number of samples	GMV	Percent of samples > 100	Geometric 90th percentile	Target GMV	Target geometric 90th percentile	Required reduction
SFSkok	10	2.3	0%	4.1	-	-	-
NFSkok	10	2.7	0%	5.6	-	-	-
MidSkok	10	3.4	0%	8.7	-	-	-
Skok101	10	11.6	0%	30.8	-	-	-
SkokChic	10	23.9	10%	90.6	-	-	-
Skok106b	10	40.1	20%	184.8	21.7	100	46%
Skok106c	5	30.4	40%	158.1	-	-	-
Vance	10	9.7	10%	52.5	-	-	-
Swift	5	4.1	0%	17.8	-	-	-
Hunter	10	21.9	0%	88.2	-	-	-
UpPurdy	10	5.8	0%	25.7	-	-	-
TenAcre	10	34.1	20%	133.2	25.6	100	25%
Weaver	10	55.0	30%	314.6	17.5	100	68%
WeavrLow	5	44.9	40%	130.2	34.5	100	23%
PurBour	10	54.3	20%	146.6	37.0	100	32%
Ikes	5	24.2	0%	64.1	-	-	-
Rods	4	21.8	0%	74.4	-	-	-
NoName1	4	21.8	0%	85.1	-	-	-
Skok106	10	32.8	20%	120.3	18.5	67.7	44%

* Class AA fresh water quality criteria for FC are: GMV <= 50, and 90th percentile <= 100 FC/100mL.
* Units for GMV and geometric 90th percentile are FC/100mL.
* Site names in bold are on the 1998 303(d) list.
* Skok106b target values are those needed to meet fresh water quality standards.
* Skok106b and Skok106c data were combined to form Skok106 as explained in the Methods section.
* Skok106 target values are those needed to protect marine water quality standards.

Water quality improvements at Weaver Creek at the West Skokomish Valley Road are expected, in part, to be seen also downstream where West Bourgault Road crosses Weaver Creek (site WeavrLow). The stream reach between these two sites contains potential sources of FC pollution, and it is expected that these would be addressed along with other potential sources in the Weaver Creek and Purdy Creek basins. Should the sampling location for the Weaver Creek basin be moved to the West Bourgault Road bridge, then target values for Weaver Creek at the West Skokomish Valley Road would need to be met at the West Bourgault Road site. Rollback targets for Weaver Creek at the West Skokomish Valley Road were used in loading analyses for representing loads from the Weaver Creek basin.

FC Load Balance

The mean daily FC load was determined for each site and used for developing load balances at key sites. The FC load was estimated for each site for each of the ten surveys during the averaging period. These individual loads were derived from the product of concentration, flow, and a conversion factor to express load in FC/day. The mean daily FC load for each site was then determined by calculating the AMV of the daily loads for each site. More sophisticated load estimation techniques (e.g., ratio estimators, regression techniques) could not be used due to insufficient flow data and lack of significant relationships between FC and flow. The AMV was used because it is more conservative than the GMV and better represents mass balance components (Parkhurst, 1998).

A FC load balance was then determined for the Skokomish River at Highways 106 and 101, and Purdy Creek at East Bourgault Road. These sites are key locations for the loading analyses, because they segment the study area and allow a more detailed look regarding FC concentrations and loads at each of these sub-basins. Figure 6a shows the distribution of FC loads for the entire study area. Figures 6b, 6c, and 6d show the relative contributions of FC load from sites above each of the three key sites. About 82% of the FC load in the Skokomish River basin is attributed to four sources: the lower mainstem corridor, Weaver Creek, Hunter Creek, and the upper mainstem corridor.

The mainstem corridor loads (residual loads) at key sites are defined as the difference between the sum of upstream loads and the load measured at that site using flow and FC data collected for that site. The upper and lower mainstem corridor loads, and the Purdy Creek corridor load, accounted for about 7%, 52%, and 3%, respectively, of the mean daily load in the Skokomish River basin. The significant residual load at the Skokomish River at Highway 106 indicates sources of FC in the lower mainstem corridor. Potential sources of FC include residences, livestock operations, and wildlife. These potential sources are also present in the upper mainstem corridor, and account for the residual load at the Skokomish River at Highway 101. Close examination of land use in the mainstem corridor will provide clues that can help better identify sources of FC and prioritize watershed cleanup efforts. Table 7 summarizes mean daily values from the study period for flow, FC concentrations, and FC loads at study sites.

Figure 6a. Distribution of mean daily FC load in the Skokomish River basin: 1999-2000 TMDL study.

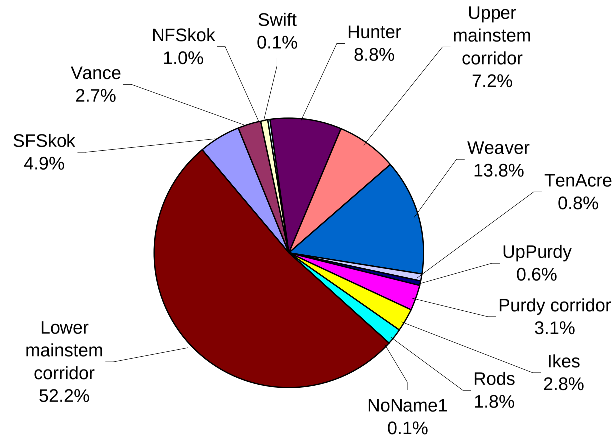

Figure 6c. Distribution of mean daily FC load in the Skok101 sub-basin: 1999-2000 TMDL study.

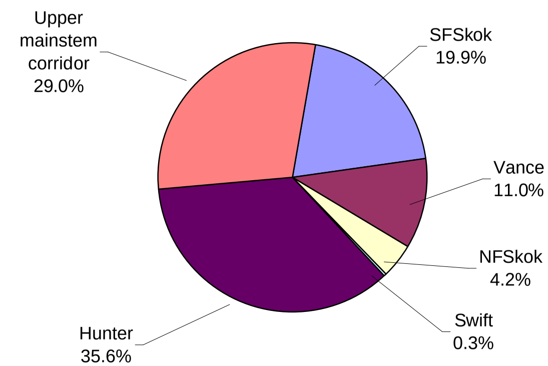

Figure 6b. Distribution of mean daily FC load in the Skok106 sub-basin: 1999-2000 TMDL study.

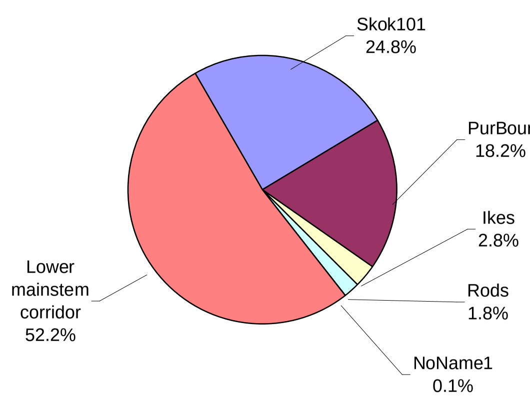

Figure 6d. Distribution of mean daily FC load in the PurBour sub-basin: 1999-2000 TMDL study.

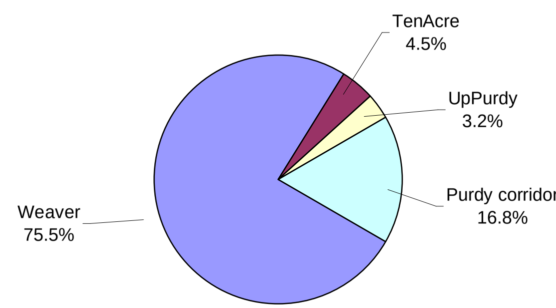

Figure 6. Distribution of mean daily FC load in the Skokomish River basin.

Table 7. Mean daily values for flow, FC, FC load, and balances at key sites for the study period.

Site	Mean flow	Mean FC	Mean FC load	Flow in whole basin	FC load in whole basin
	CFS	FC/100mL	FC/day	%	%
Skok101 sub-basin					
SFSkok	829.4	2.6	6.61E+10	51%	5%
Vance	230.4	23.1	3.65E+10	14%	3%
NFSkok	160.9	3.2	1.38E+10	10%	1%
Swift	5.7	7.6	9.54E+08	0%	0%
Hunter	154.1	32.7	1.18E+11	9%	9%
subtotal to Skok101	1380.5	-	2.35E+11	-	-
Skok101 residual	38.2	-	9.62E+10	2%	7%
Skok101 observed	1418.7	14.8	3.31E+11	-	-
Skok101 summed	1418.7	-	3.31E+11	-	-
residual/Skok101 observed	3%	-	29%	-	-
PurBour sub-basin					
Weaver	47.7	161.0	1.84E+11	3%	14%
TenAcre	8.6	52.3	1.10E+10	1%	1%
UpPurdy	34.4	10.9	7.80E+09	2%	1%
subtotal to PurBour	90.7	-	2.03E+11	-	-
PurBour residual	26.0	-	4.09E+10	2%	3%
PurBour observed	116.7	75.6	2.44E+11	-	-
PurBour summed	116.7	-	2.44E+11	-	-
residual/PurBour observed	22%	-	17%	-	-
Skok106 sub-basin					
Skok101 summed	1418.7	14.8	3.31E+11	87%	25%
PurBour summed	116.7	75.6	2.44E+11	7%	18%
Ikes	51.6	30.1	3.78E+10	3%	3%
Rods	38.7	28.9	2.42E+10	2%	2%
NoName1	2.4	30.4	1.75E+09	0%	0%
subtotal to Skok106	1628.0	-	6.39E+11	-	-
Skok106 residual	0.0	-	6.99E+11	-	52%
Skok106 observed	1628.0	55.0	1.34E+12	-	-
Skok106 summed	1628.0	-	1.34E+12	100%	100%
residual/Skok106 observed	0%	-	52%	-	-

FC Load Allocation

The recommended load allocations for FC were derived after reviewing different load allocation scenarios. Five scenarios were examined to determine how and if target reductions in FC values could be met. The scenarios used the mean daily flow from the averaging period with various FC values to calculate FC loads. Mass balance calculations in each scenario were used to predict FC values and compare those to target values. Different FC values were assigned to upstream sites, and their effects on target levels at downstream sites were examined. The five loading scenarios are described in Appendix D and the recommended allocation is discussed below.

The recommended load allocations, also expressed as target FC GMVs and 90^{th} percentile values, for the lower Skokomish River basin are shown in Table 8. The target GMVs for the Skokomish River at Highway 106, Weaver Creek at West Bourgault Road, TenAcre Creek at the West Skokomish Valley Road, and Purdy Creek at East Bourgault Road are 18.5, 17.5, 25.6, and 25.7 FC/100mL, respectively. The corresponding 90^{th} percentiles are 67.7, 100.0, 100.0, and 69.4 FC/100mL, respectively. These allocations represent reductions over study values of 44%, 68%, 25%, and 53%, respectively.

The recommended targets for the Skokomish River at Highway 101 and Hunter Creek at the West Skokomish Valley Road are GMVs of 11.6 and 21.9 FC/100mL, respectively. The corresponding 90^{th} percentiles are 30.8 and 88.2 FC/100mL, respectively. These targets are the same values found during the study and thus reflect no change.

The recommended target values for Purdy Creek at East Bourgault Road are a GMV of 25.7 FC/100mL and a 90^{th} percentile of 69.4 FC/100mL. The targets for Purdy Creek represent a 53% reduction over study values. The targets for Purdy Creek should be met when Weaver and TenAcre creeks meet their targets and other FC inputs do not exceed those found during the study period.

The large FC load along the lower mainstem corridor will need to be reduced by 66% in order for the Skokomish River at Highway 106 to meet its target values. Allocations for the upper mainstem and Purdy Creek corridors are the same as those found during the study. Figures 7a-7d show the distribution of FC loads using the recommended target FC values. Figure 8 compares the distribution of FC loads found during the study with FC loads at the recommended allocations.

Two sites that were on the 1998 303(d) list were not monitored. Purdy Creek at its mouth is expected to meet water quality standards when upstream sites meet their targets. The Skokomish River at Bobby Allens may be influenced by FC sources downstream of the Highway 106 bridge and also by additional flow contribution. This site would likely need to meet, at a minimum, the FC targets set for the Highway 106 site in order to be protective of marine water quality standards. Water quality monitoring at this site should be considered in future monitoring efforts.

Table 8. Recommended FC TMDL load allocations for Skokomish River sub-basins.

Site	1996 303(d) list	1998 303(d) list	Study FC GMV FC/100mL	Study FC geometric 90th percentile FC/100mL	Target FC GMV FC/100mL	Target FC geometric 90th percentile FC/100mL	Required change %	Target FC load (allocation) FC/day
Lower mainstem corridor	no	no	not monitored	not monitored	not determined	not determined	-66%	2.41E+11
Weaver Creek	**yes**	**yes**	55.0	314.6	17.5	100.0	-68%	5.86E+10
TenAcre Creek	**yes**	**yes**	34.1	133.2	25.6	100.0	-25%	8.23E+09
Purdy Creek (E Bourgault Rd)	**yes**	**yes**	54.3	146.6	25.7	69.4	-53%	1.16E+11
Skokomish River at Hwy 106 [1]	**yes**	**yes**	32.8	120.3	18.5	67.7	-44%	7.52E+11
Hunter Creek	**yes**	**yes**	21.9	88.2	21.9	88.2	0%	1.18E+11
Skokomish River at Hwy 101 [1]	**yes**	**yes**	11.6	30.8	11.6	30.8	0%	3.31E+11
Upper mainstem corridor	no	no	not monitored	not monitored	not determined	not determined	0%	9.62E+10
Purdy Creek corridor	no	no	not monitored	not monitored	not determined	not determined	0%	4.09E+10
Purdy Creek at mouth [2]	**yes**	**yes**	not monitored	not monitored	not determined	not determined	not determined	not determined
Skokomish River at Bobby Allens [3]	**yes**	**yes**	not monitored	not monitored	not determined	not determined	not determined	not determined
Vance Creek	no	no	9.7	52.5	9.7	52.5	0%	3.65E+10
NoName1 Creek [4]	no	no	28.5	44.6	28.5	44.6	0%	1.75E+09
North Fork Skokomish River	no	no	2.7	5.6	2.7	5.6	0%	1.38E+10
Upper Purdy Creek	no	no	5.8	25.7	5.8	25.7	0%	7.80E+09
South Fork Skokomish River	no	no	2.3	4.1	2.3	4.1	0%	6.61E+10
Ikes Creek [4]	no	no	28.5	42.6	28.5	42.6	0%	3.78E+10
Rods Creek [4]	no	no	25.8	49.2	25.8	49.2	0%	2.42E+10
Swift Creek [4]	no	no	5.9	15.2	5.9	15.2	0%	9.54E+08
Skokomish River at Rocky Beach	**yes**	no	not monitored	not monitored	not determined	not determined	not determined	not determined
Skokomish River at Chico's Eddy	**yes**	no	23.9	60.0	not determined	not determined	not determined	not determined
Weaver Creek (W Bourgault Rd)	**yes**	no	use Weaver Creek data	use Weaver Creek data	see target for Weaver Creek	see target for Weaver Creek	not determined	see target for Weaver Creek

[1] Target levels should be reached if upstream sites met or bettered their allocated loads.
[2] Expected to meet water quality standards when Purdy Creek at E Bourgault Rd meets target FC levels.
[3] Monitoring is needed to see if this site at least meets FC target values for the Skokomish River at Hwy 106.
[4] FC values differ from Table 6 values due to estimation methods - see text.
Bold - 303(d) listings

Figure 7a. Distribution of mean daily FC load in the Skokomish River basin at recommended TMDL allocations.

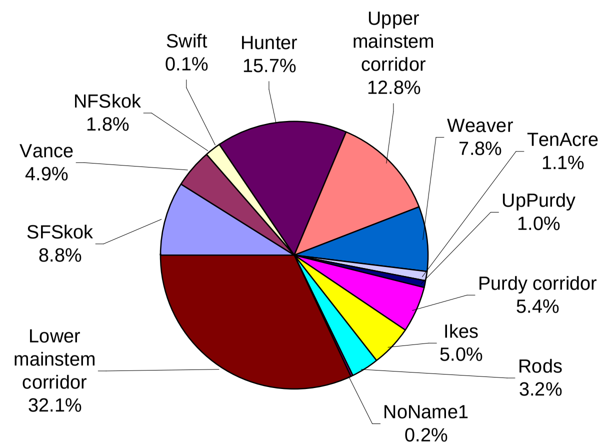

Figure 7c. Distribution of mean daily FC load in the Skok101 sub-basin at recommended TMDL allocations.

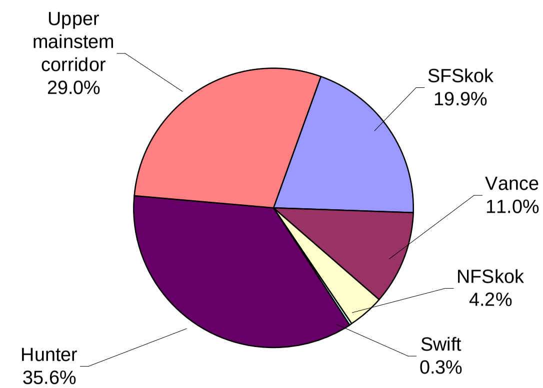

Figure 7b. Distribution of mean daily FC load in the Skok106 sub-basin at recommended TMDL allocations.

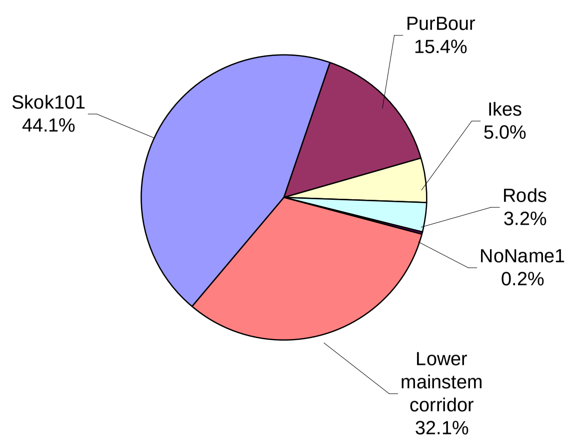

Figure 7d. Distribution of mean daily FC load in the PurBour sub-basin at recommended TMDL allocations.

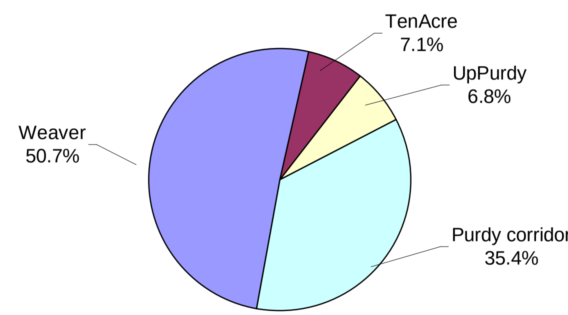

Figure 7. Distribution of mean daily FC load in the Skokomish River basin at recommended TMDL allocations.

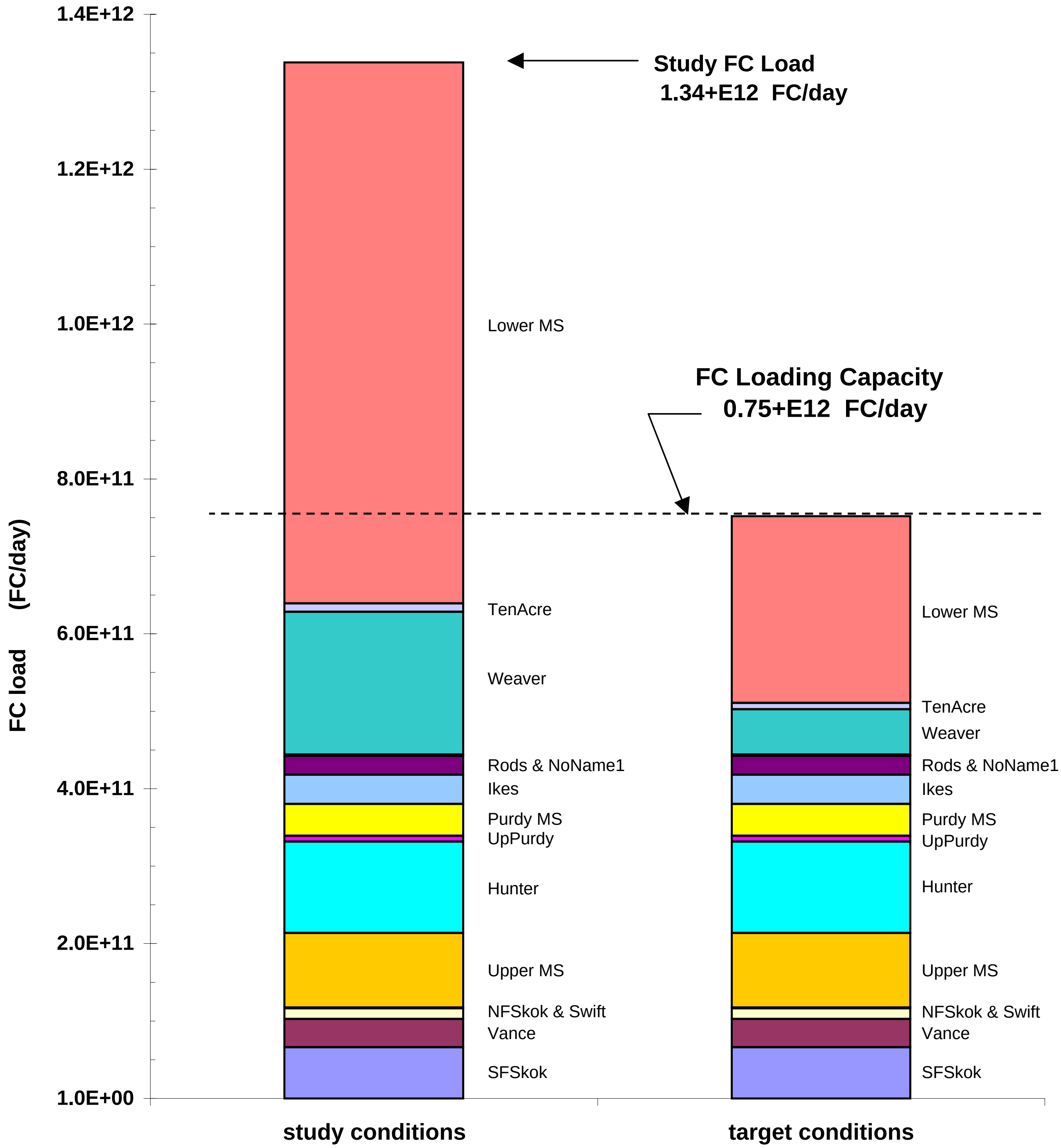

Figure 8. Comparison of FC load distributions at study and target conditions.

Achievement of the recommended target FC levels must consider the effects from the FC loads of non-303(d)-listed streams. In the recommended load allocation scenario, non-303(d)-listed streams were given FC values that were the same as those found during the study. The mixture of 303(d)-listed and non-303(d)-listed streams results in a situation where loads from non-listed streams can adversely affect the target values required by sites downstream. These adverse effects can be offset by adequately balancing contributing loads such that target values are met. Hence, the FC levels for sites not 303(d) listed can vary, as long as their combined effect allows downstream sites to meet their targets.

The planning of efforts to manage FC sources needs to consider the various jurisdictions and authorities within the study area. The TMDL allocation scheme includes Skokomish Reservation and non-Reservation land. Only the non-Reservation areas are under the jurisdiction of Washington State. The EPA and the Tribe have Clean Water Act jurisdiction for parts of the watershed that are within the boundaries of the Reservation. For example, Ikes and Rods creeks have specific allocations. The allocation for the lower mainstem corridor includes both Tribal and non-Tribal jurisdictions, and does not give separate allocations for each jurisdiction. Separate allocations for each jurisdiction along this lower mainstem corridor could be developed in the future and may require water quality monitoring and a thorough land use evaluation. All jurisdictions should consult one another about the roles they plan to take in identifying and managing FC sources within their jurisdiction.

A load allocation was not assigned to wildlife because quantitative information was lacking on this potential source. Should the contribution of wildlife to FC loads be deemed substantial, wildlife would be considered a natural source and given its own load allocation. This would result in smaller load allocations to human-related FC sources (e.g., septic systems, livestock management) and require that greater reductions be achieved where the sources are manageable. Such a revision to this TMDL can occur at a future date. There are no point sources of FC in the study area, so wasteload allocations are not needed.

Margin of Safety

A margin of safety to account for scientific uncertainty must be considered in TMDLs in order for load allocations to remain protective. The margin of safety for this TMDL is implicit; it is contained within conservative assumptions used to develop the TMDL. Factors contributing to a margin of safety are:

- The simple mass balance calculations and subsequent derivation of target values in fresh water assumed no FC die-off. Mass-balance calculation for FC from Skokomish River to Annas Bay also used simple dilution and disregarded FC die-off in the marine waters.
- Arithmetic means, rather than geometric means, for FC and flow were used in mass balance calculations. The advantage of using the arithmetic mean is that it is not biased low (as is the geometric mean) and therefore is more protective of water quality and public health.
- The rollback method assumes that the variance of the pre-management data set will be equivalent to the variance of the post-management data set. As pollution sources are managed, the occurrence of high FC values is likely to be less frequent, and thus reduce the variance and the 90th percentile of the post-management condition.

- Ecology FC data were used since they provide greater protection than the use of combined Ecology and Tribal data.
- The North Fork Skokomish FC load is an overestimate, because it is based on a higher flow (at RM 10.10) than that associated with the actual sample site (RM 12.5). Several tributaries enter the stream between the sample site and the point of flow measurement.

Monitoring and Implementation

Monitoring and implementation efforts should focus on three areas: (1) investigation of potential or actual sources of FC pollution, (2) tracking the implementation and maintenance of non-point pollution controls, and (3) monitoring water quality to determine compliance with target values. An evaluation of available resources will help define the roles and expectations that local, state, and Tribal governments have in implementing pollution management and monitoring actions.

A detailed plan for each of the three efforts above should be developed that identifies specific tasks with quantifiable goals and timeframes. For example, the investigation and recording of potential or actual pollution sources should be accomplished within six months of adopting the detailed implementation plan. Another goal could be to meet target FC levels in Weaver Creek within two years of adopting the detailed implementation plan.

Identification of potential or actual sources of FC pollution is needed to help focus cleanup actions in areas where the greatest benefit can be gained. An initial examination of land uses, agricultural practices, and on-site septic system practices can help in prioritizing cleanup actions. Particular attention should be given to areas of known residential or agricultural land use, such as the lower and upper mainstem river corridors and stream corridors associated with Weaver and TenAcre creeks. Although not within the study area, land-use practices adjacent to the mainstem and sloughs downstream of the Highway 106 bridge should be evaluated for their FC pollution potential.

Information about the implementation and maintenance of water cleanup plan actions should be kept current by tracking all cleanup activities and reporting then on a regular basis, perhaps annually. Information about the location, magnitude, and management of FC sources is critical for ensuring that pollution control efforts are focused and will provide the greatest benefit for resources invested.

Water quality monitoring is needed to determine compliance with the FC load allocations and to help evaluate the effectiveness of pollution management actions. Monitoring should be based on a 12-month period; the 10-month averaging period was used only to develop the TMDL. Water quality monitoring for FC at the Skokomish River at Highway 106, Purdy Creek at East Bourgault Road, Weaver Creek, and TenAcre Creek is needed to determine compliance with water quality standards and the TMDL targets. Should FC target levels not be met, additional monitoring at other sites (particularly the Skokomish River at Highway 101) may be needed to determine sources of FC loading.

Specific monitoring considerations are:

- The water quality monitoring program that the Tribe conducts should be actively supported. It has the potential to meet many of the TMDL monitoring needs.

- The Skokomish River at the Highway 106 bridge (site Skok106) should be the main point to monitor for compliance with the TMDL. The monitoring of this site could be carried out by Ecology's Environmental Monitoring and Trends Section (EMTS), the Skokomish Tribe, Mason County, or other group. This site should be sampled from the center of the highway bridge rather than from the bank. Use of a weighted device to lower and raise the FC sampling bottle would facilitate this.

- The possibility of moving Ecology's EMTS site from the Highway 101 bridge to the Highway 106 bridge should be investigated. Ecology's EMTS is likely to continue monthly monitoring of FCmf at the Skokomish River for some time.

- Water quality results from EMTS monitoring of FCmf at the Skokomish River at Highway 101 site could be used for determining compliance with the FC target levels only at that site. Results from the EMTS efforts would be of limited use for determining compliance with target levels at other sites. If FCmf data from the EMTS effort are to be used, FC values could be estimated from the FCmf values by using the regression relationship between FCmf and FC as established in Appendix A.

- The analysis of FC samples should use the multiple tube fermentation technique, since the Tribe and DOH use this technique in their monitoring programs. The use of different indicators of microbial water quality should be evaluated as those indicators come into use. For example, Ecology may adopt a different bacteria group, *Enterococcus,* for evaluating water quality in the future.

- Weaver Creek at the West Bourgault Road bridge, rather than at the bridge on the West Skokomish Valley Road, should be used for monitoring the Weaver Creek basin. The site at the West Bourgault Road bridge is downstream of most of the human-impacted land in the Weaver Creek basin. The target FC value derived for Weaver Creek at the West Skokomish Valley Road should be used; it would be conservative and likely result in Weaver Creek meeting the target FC value.

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Conclusions and Recommendations

Conclusions

- Class AA fresh water quality criteria in the lower Skokomish River basin are inadequate for protection of the marine water quality standards applied in Hood Canal. Most, if not all, streams in the lower Skokomish River basin must have FC levels well below Class AA fresh water criteria in order to protect the marine waters and their beneficial uses.

- Reductions of FC concentrations are needed in the Skokomish River at Highway 106 to protect marine water quality standards. A GMV of 18/100mL and a 90th percentile of 68/100mL FC would be protective of the beneficial uses of Annas Bay and Hood Canal. These target values represent a 44% reduction from study results.

- To meet fresh water quality standards, reduction of FC concentrations are needed in Purdy Creek at East Bourgault Road, Weaver Creek at West Bourgault Road, and TenAcre Creek where it meets the West Skokomish Valley Road. The target GMVs for these sites are 26, 17, and 26 FC/100mL, respectively. The corresponding target 90th percentiles are 69, 100, and 100 FC/100mL, respectively.

- Concentrations of FC should not exceed study values for the Skokomish River at Highway 101 and Hunter Creek at the West Skokomish Valley Road. Study values were GMVs of 12 and 22 FC/100mL, respectively, and corresponding 90th percentiles of 31 and 88 FC/100mL, respectively.

- Most (52%) of the FC load comes from the lower mainstem corridors of the Skokomish River and Purdy Creek, between the bridges for Highways 106 and 101, and East Bourgault Road. Weaver and Hunter creeks contributed the next largest loads (14% and 9%, respectively).

- The Purdy Creek mouth site, a 303(d)-listed site, is expected to meet water quality standards as a result of implementing actions under a water cleanup plan. The Purdy Creek mouth site was not monitored during this study due to logistical and resource considerations.

- The Skokomish River mouth site, referred to as "Bobby Allens" in the Tribe's 1997 report, was not monitored during this study; the Skokomish River site at the Highway 106 bridge was considered a more practical site for determining fresh water FC concentrations and loads. While FC levels are expected to decrease at the mouth site due to the implementation of a water cleanup plan, additional monitoring may be needed to determine if FC levels here remain protective of marine water quality standards. Target FC levels (load allocations) for the Skokomish River mouth site were not developed during this study, but will need to be equal to or below the target levels for the Skokomish River at Highway 106.

- Wildlife sources were not given a separate FC load allocation, because quantitative information about all potential FC sources was lacking. The contribution of wildlife to FC loads would be considered a natural background level and given a separate load allocation. This would result in reduced load allocations to human-controlled FC sources (e.g., septic systems, livestock management). There are no point sources of FC in the basin, so a wasteload allocation is not needed.

- Dissolved oxygen (DO) levels in most of the tributary sites did not meet the Class AA water quality standard criterion of 9.5 mg/L. Possible contributors to low DO include groundwater inputs that are low in DO, wetland areas exerting a biological oxygen demand from decay of organic material, and loading of organic material in streams from human activities such as agricultural and fish hatchery operations. Causes for depressed DO levels were not determined during this study.

- This TMDL and its load allocations include Reservation and non-Reservation areas upstream of the Highway 106 bridge. The EPA and the Tribe have Clean Water Act jurisdiction for parts of the watershed that are within the boundaries of the Reservation, while Washington State has jurisdiction for areas outside the Reservation. A cooperative effort among local residents and Tribal, local, and state governments will be needed to address jurisdictional issues that may arise as a water cleanup plan is developed and implemented.

- The 1999-2000 Tribal data that were collected concurrent with Ecology's TMDL sampling effort were comparable to Ecology data. Ecology data were used for TMDL analyses in order to develop more conservative target FC levels.

Recommendations

- Collaborate with interested parties, local government, the Skokomish Tribe, and EPA in the development and implementation of a water cleanup plan for reducing FC pollution.

- Evaluate land use practices in areas draining to the monitored sites to better determine sources of bacterial pollution. A survey of all on-site sewage systems and agricultural operations in the highest priority areas, the 303(d)-listed sites, should be conducted. A prioritization of sites in Table 8 can help focus survey and cleanup efforts in the most important areas contributing to FC loading.

- Install portable toilets at popular fishing locations along the river's right bank, particularly in the area of Highway 106 and along the Purdy Cut-Off Road. Post signs in this area to inform anglers of the FC problem and to encourage them to use the facilities.

- Develop and implement a long-term monitoring program to determine the effectiveness of pollution control actions and compliance with the TMDL allocation targets.

- Track all efforts related to the development and implementation of a water cleanup plan. Future TMDL evaluation may include the review and quantification of efforts taken as part of the water cleanup plan.

- Investigate DO levels in streams that fail to meet water quality standards (Table 4). Further characterize the extent, and possible causes, of low DO through water quality monitoring and land use evaluation. Investigate and characterize nutrient loading from fish hatcheries. These streams should be listed on the next 303(d) list. Possible causes of depressed DO include groundwater input that is low in DO, wetland areas exerting a biological oxygen demand (BOD) from decay of organic material, and loading of organic material or nutrients to streams from human activities such as agricultural and fish hatchery operations.

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Appendices

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Appendix A. Quality Assurance and Quality Control.

The Quality Assurance Project Plan (QAPP), by Hoyle-Dodson and Pickett (1999), describes procedures that were followed for the collection and analysis of laboratory samples and for measurements made in the field. Water quality data from Ecology's Environmental Monitoring and Trends Section were used. Chain-of-custody security procedures were followed for 74% of samples sent to the laboratory. All general chemistry samples met holding time requirements. Microbiology samples were analyzed within 30 hours, which is a standard procedure for Ecology's laboratory. Microbiology samples were not analyzed within the 6-hour window described in Standard Methods (APHA, 1992) because of the logistical challenges in collecting and transporting samples within this timeframe (Jensen, 2000).

Precision

Laboratory data were generated according to Quality Assurance/Quality Control (QA/QC) procedures followed by Manchester Environmental Laboratory (Ecology, 1994). Replicate samples were used to estimate sampling precision expressed as the pooled standard deviation (Ecology, 1991). Replicate precision generally met the 50% Relative Percent Difference (RPD) target for bacteria samples. Two replicate FCmf samples had RPDs of 57% and 73%. This was deemed acceptable in the context of all replicate data. Where bacteria values were greater than ten times the detection limit, replicate precision met the target for RPD. Laboratory data were deemed acceptable as qualified in Appendix A2. For results reported as non-detects at a given detection limit, the reported detection limit was used in analyses. Laboratory-determined conductivities were used where available, generally prior to September 1999.

Replicate precision met the 10% RPD target described in the QAPP (Hoyle-Dodson and Pickett, 1999) for conductivity, dissolved oxygen, and temperature. Reported field conductivities compared favorably with laboratory conductivities with RPDs less than 10%. Field data reported here were deemed acceptable as qualified in Appendix A2. Table A1 summarizes QA data.

Completeness

Collection of water quality data was deemed complete. Water quality data were generally collected at planned times and frequencies with the exception of storm-event sampling. The objective to characterize bacteria concentrations during storm-events was abandoned due to logistical challenges and resource limitations. Two FC results from a single storm-event on 5/17/99 are included in Appendix A2 but were not included in any analyses. Additional wet-season sampling for FCmf was added to the regular monthly sampling frequency; samples were collected at five sites approximately two weeks after the routinely scheduled monthly sampling for October 1999 - January 2000.

Collection of streamflow data was incomplete. Numerous difficulties presented themselves such that continuous hydrographs and instantaneous flow measurements at many sites were either not collected or had spotty records of uncertain quality. Problems included logistical challenges,

Table A1. Precision estimates for Ecology water quality data.

Parameter	Number of replicate pairs	Number of analyses	Replicate rate	Pooled Standard Deviation	95% CI for any single result	RMSCV	units
Ecology Replicates							
Fecal Coliform - mpn (lab)	17	184	9%	5.8	11.9	44%	#/100 mL
E. coli - mpn (lab)	17	184	9%	5.0	10.2	41%	#/100 mL
Fecal Coliform - mf (lab)	21	193	11%	6.8	13.8	41%	#/100 mL
Total Suspended Solids (lab)	21	204	10%	0.5	1.1	14%	mg/L
Conductivity (lab)	14	107	13%	2.0	4.1	3%	umho/cm
Conductivity (field)	4	217	2%	1.9	4.5	3%	umho/cm
Conductivity (lab vs field: > 8/99)	11	137	8%	3.1	6.4	4%	umho/cm
Dissolved Oxygen (field)	12	120	10%	0.2	0.3	1%	mg/L
Temperature (field)	4	229	2%	0.0	0.0	0%	degree C
Flow (field)	0	49	0%	-	-	-	cfs
Cond (lab vs field: <= 8/99)	84	84	100%	6.8	13.4	12%	umho/cm
Cond (lab vs field: 1/99-1/00)	95	221	43%	6.5	12.8	11%	umho/cm

CI = Confidence Interval

RMSCV = Root Mean Square of the Coefficient of Variation

equipment problems, and staffing shortages. This loss of information necessitated using a variety of techniques to estimate flows at sites of interest for the study period. These estimation techniques are discussed in Appendix B.

Representativeness

Study design and collection methods were intended to be representative of an annual cycle at the sites that were sampled. Samples were systematically collected at monthly intervals, or twice per month for several sites. A range of flow and antecedent precipitation conditions were represented on days samples were collected. The estimated mean daily FC loads for sites were derived from a relatively small number of observations (n=10) and used a simple averaging approach. These load estimates may be less accurate than those gained by other approaches (Richards, 2000). Unfortunately, more sophisticated load estimation techniques (e.g. ratio estimators, regression techniques) could not be used due to insufficient flow data. Obtaining more accurate estimates of FC loading would involve a larger monitoring effort yet the cost of such effort may outweigh its benefit: it is unlikely that greater accuracy would appreciably change the development and implementation of pollution management strategies.

Sample sites were generally representative of the stream section being sampled. Two sample sites, however, may not always be representative of the stream sampled because of potential influence from upstream inputs. This applies to samples collected by Ecology and the Skokomish Tribe. The sites are:

- The Skokomish River at Chico's Eddy (SkokChic) - the bank sample location is about 20 yards downstream of the confluence of Ikes Creek with the Skokomish River. While this sample site appears to be well mixed at some flows, the possibility exists that Ikes Creek influenced the samples collected at this point in the river.

- The bank site at the Highway 106 bridge (Skok106b) – this site is immediately downstream of a small tributary (NoName1) and is located in a back-eddy area used to launch boats. While the flow from the small tributary is minimal, the back-eddy nature of the site and its being out of the main flow of the Skokomish River make this a less than ideal site representative of the Skokomish River. Ecology began sampling from the center of the Highway 106 bridge (Skok106c) in August 1999 in addition to collecting samples at the bank.

  Results from Ecology's bridge and bank sampling were compared using a paired sample t-test. Results of this test indicate no difference between the two data sets for FCmpn (n=5). The high variability and low n of the FC data used in the paired tests likely contribute to the test result showing no difference between the two data sets. The paired t-test for conductivity showed that the two data sets were different. The Skok106b conductivity values were generally higher than the Skok106c values, most likely due to the influence of NoName1 creek water present at Skok106b - the creek originates from springs on the southern valley wall and floor. While sample results from the bank site provide some information about FC in the Skokomish River, observations and data suggest that the site is not representative.

Comparability

Field and laboratory methods used by Ecology during this survey were consistent with methods widely used today. Comparability of specific data sets should be evaluated on a case-by-case basis. Some data collected during this study presented questions about comparability, such as comparability of FCmf and FCmpn; of Ecology FCmpn and Tribal FCmpn. These are described below.

Comparison of FCmpn with FCmf, and FCmpn with E. coli

Different bacteria enumeration methods are used by various monitoring efforts in the Skokomish basin and the comparability of these were evaluated. Ecology's ambient monitoring station 16A070 (Skok101) contains bacteria data evaluated using the FCmf data whereas the Skokomish Tribe uses the FCmpn method. The comparability of Ecology's FCmpn and FCmf results was evaluated.

The paired t-test and the Wilcoxon paired-sample test were performed on "paired" FCmpn and FCmf data (n=190 and 180, respectively). Test results indicate that FCmpn and FCmf results are not comparable. A relationship was established between FCmpn and FCmf in order to potentially allow FCmf values to be used with FCmpn data in TMDL analyses. The equation for this relationship is: FCmf = 0.8803* FCmpn ^ 0.8955 (R2=0.76). It appears that violations of the water quality standards for bacteria would be more sensitive to bacteria data generated by the FCmpn method. Implications of using the FCmf method for evaluating compliance with water quality standards should be examined.

The fecal coliform bacteria sub-group *Escherichia coli* (*E.coli*) was also enumerated using the mpn technique. Linear regression of FCmpn against *E.coli* indicates that the FCmpn bacteria found in during the study are comprised almost wholly of the genus *E.coli*. The equation for the relationship is: *E.coli* = 0.9901 * FCmpn ^ 0.9802 (R2=0.98). *E.coli* was determined in anticipation of a potential change in the water quality standard for bacteria at the time of project planning.

Comparison of Ecology and Skokomish Tribal Data

Tribal data collected concurrent with Ecology's TMDL sampling effort were deemed comparable to Ecology data. Tribal data prior to 1999 were not included in analyses for the TMDL since less is known about the quality of those data and other necessary data are lacking (e.g. dates and times, flows). However, Tribal data collected prior to 1999 should be of adequate quality for characterizing water quality and identifying problem areas if these data were collected with similar quality assurance procedures. If Tribal data quality is maintained, future Tribal monitoring can be used to determine compliance with the TMDL load allocations.

Sample collection and laboratory methods were reviewed and deemed comparable. Ecology and the Thurston County Environmental Health lab both used the Most Probable Number (MPN) technique for enumerating FC bacteria. Holding times for the two labs were different and this is a common factor in comparison of Ecology FC data to non-Ecology FC data. Ecology may hold FC samples for up to 30 hours whereas the holding time used by the county lab is six hours. Ecology adopted the 30-hour holding time some years ago with EPA's approval to allow processing of samples from Ecology's many sampling activities all over the state.

Two statistical analyses were done to determine if there were differences between Tribal and Ecology data. The paired t-test and the Wilcoxon paired-sample test were performed on the entire "paired" data set (n=89) as well as paired sets from seven streams (n=12 or 13). The paired t-tests and Wilcoxon paired-sample tests found no difference between Tribal and Ecology data sets.

Estimates of precision for the Tribal-Ecology paired data were also compared to estimates of precision for Ecology's field replicate pairs and the thresholds stated in the QAPP for the Skokomish TMDL. The threshold in the QAPP was a Root Mean Square of the Coefficient of Variation (RMSCV) of no greater than 50%. Bacteria values used in these estimates of precision were greater than 10 times the detection limit. The pooled standard deviation and RMSCV values for the Tribal-Ecology paired data were higher than those found for Ecology's field replicate samples and may reflect the use of two different labs. The RMSCV for four of the sites exceeded Ecology's threshold for field replicate precision; three by several percent while one by 13% (SkokChic). The high RMSCV for SkokChic could be due in part to poor mixing at this site and the influence of Ikes Creek as discussed below. The overall RMSCV for the eight sites was 50%, which was the threshold limit defined in the QAPP. These RMSCVs at the threshold value indicate potential borderline problems with comparability of Ecology and Tribal FCmpn data. A scatterplot of Ecology and Tribal FCmpn data suggests that Ecology's FCmpn values may be biased high, at values above 20 FC/100mL, as compared to corresponding Tribal FCmpn values. Table A2 summarizes the comparisons of Tribal and Ecology estimates of precision.

Another comparison of the Ecology and Tribal data sets was performed by comparing each data set to the water quality standards and to each other's rollback targets (Table A3). The Ecology data show that four sites did not meet standards whereas the Tribal data show only two sites that did not meet standards. Differences in study values and target values for the GMV and 90th percentile are also apparent. These results may reflect the apparent bias between the two data sets as discussed above. The statistical tests described above for comparing the two data sets are not necessarily accurate indicators of how the two data sets perform when the water quality standards criteria are applied to them. In considering the need for a Margin of Safety in the TMDL, the Ecology data were selected for TMDL and load allocation analyses because their use results in a more conservative approach than using Tribal or pooled data.

Table A2. Precision estimates for Ecology and Tribal paired FC data.

	Number of replicate pairs	Pooled Standard Deviation	RMSCV
Ecology Field Replicate Pairs			
Fecal Coliform - mpn	6	8.1	19%
Tribal-Ecology Pairs (by site)			
All sites - FCmpn	64	97.3	50%
Hunter- FCmpn	8	15.1	43%
PurBour - FCmpn	13	92.4	53%
Skok106b - FCmpn	12	80.4	34%
SkokChic - FCmpn	7	56.5	63%
TenAcre - FCmpn	10	35.1	53%
Vance - FCmpn	5	27.7	48%
Weaver - FCmpn	9	204.7	54%

Only FCmpn values greater than 10/100mL were used for estimating precision.

RMSCV = Root Mean Square of the Coefficient of Variation

Table A3. Comparison of Ecology and Tribal FC data summaries and target rollback reductions for the study period.

	Ecology data					*Tribal data*				
Site	n	GMV	Geometric 90th percentile	Target GMV	Required reduction	n	GMV	Geometric 90th percentile	Target GMV	Required reduction
SkokChic	10	23.9	90.6	-	-	10	17.7	44.6	-	-
Skok106	10	32.8	120.3	18.5	44%	10	33.6	89.1	18.5	36%
Vance	10	9.7	52.5	-	-	10	10.2	26.9	-	-
Hunter	10	21.9	88.2	-	-	10	15.1	44.0	-	-
TenAcre	10	34.1	133.2	25.6	25%	10	34.8	78.9	-	-
Weaver	10	55.0	314.6	17.5	68%	10	39.6	142.8	27.7	30%
PurBour	10	54.3	146.6	37.0	32%	10	44.9	158.2	28.4	37%

* Units for GMV and geometric 90th percentile are FC/100mL.

* The target geometric 90th percentile for all sites is 100 FC/100mL, except for Skok106 which is 67.7 FC/100mL.

Appendix B. Flow Measurement Techniques.

Flow Measurements

Streamflows were determined for all sites on 34 separate dates using a variety of techniques. Eighteen of the 34 dates coincided with water quality sampling. Techniques used were:

- Daily average and instantaneous estimates from USGS gaging sites,
- Instantaneous measurements by Ecology,
- Instantaneous estimates from Ecology reference point rating curves,
- Daily average and instantaneous estimates from Ecology continuous stage recorder,
- Instantaneous and daily average estimates from inter-basin regressions,
- Instantaneous estimates from seasonal stage pattern over time (for groundwater dominated streams),
- Instantaneous estimates from the averaging of instantaneous measurements (for groundwater dominated streams),
- Instantaneous estimates from flow balance relationships (sums and regressions).
- Instantaneous estimates from nearby dates having similar antecedent rainfall conditions.

Instantaneous measurements and rating curve development generally followed procedures described in Ecology (1992). Daily average flow data from USGS were used for three sites on the Skokomish River (sites SFSkok, NFSkok, and Skok101). USGS calculates the daily average flow using the trapezoidal method which is an integration of the hydrograph (USGS, 1997). McKernon Hatchery flows were reviewed to help characterize the seasonal nature of groundwater flow in the lower valley (groundwater supplies the McKernon Hatchery with water for its operations).

Continuous stream stage recorders were installed at several sites. Stage height was measured every 15 minutes and stored in a datalogger. The continuous record of stage height from these instruments was broken up due to equipment problems and flood events. For periods of reliable operation, stage-height data were examined and corrected for changes in the instrument package or instrument location relative to the site-specific reference point. Instrument drift was not examined or corrected with the stage recorders. Relationships of instrument probe values to fixed reference points were developed in order to develop a continuous record stage height that corresponded to the reference point for that site. These relationships are shown in Table B1.

Stage-height to streamflow relationships were developed for most sites. Stage height was related to a fixed reference point such as a staff gage or point on a bridge above the stream. For each site, various regressions of stage height to measured streamflow were examined and the most appropriate one was used to estimate flow. Table B2 shows these relationships and the conditions under which they apply. More than one relationship was developed for some sites in order to cover various conditions that changed the nature of the relationship (e.g. reference point being moved, high or low flow conditions, storage and release conditions during high flow events). Flow values from a midnight to midnight period were arithmetically averaged to produce a daily average flow value for that site on days of interest.

Inter-basin relationships were developed and used to estimate flows where no data existed (Table B2). Flows from Vance were regressed against flows from SFSkok, thus allowing flow estimates of Vance when data were missing. Ikes and Rods creek flows were regressed against estimated flow values from Hunter or Weaver creeks.

Storage and release from the wetland complex at PurBour made the development of a rating curve challenging. High water levels in the Skokomish River appeared to increase the water level in the wetland area where PurBour is located. Flow measurements made during storage or release periods were unrepresentative of streamflow from the PurBour watershed. To determine the times when representative flows at PurBour occurred, stage and flow plots PurBour were examined in conjunction with the stage record for the Skokomish River near Potlatch (USGS site 12061500 – just upstream of the Highway 101 bridge). Of the six flow measurements made at PurBour, three appeared to be during periods that the Skokomish River was not influencing the wetland complex (Skokomish River flow < 1200 cfs and no runoff events in previous three to five days). These three flows were then regressed against summed flow values from upstream sites (Weaver, Purdy, and TenAcre). This regression was then used to estimate all flows at PurBour.

Flow data from USGS were obtained from the USGS Tacoma office via the Automated Data Processing System (ADAPS) database. The data used for this study were reviewed by USGS staff at special request in order to allow timely analysis and reporting of this project's results. USGS still considers these data "provisional" a status that lasts for one to two years after date of determination until data are fully reviewed in the context of other regional information and declared "final" (Kresch, 2000). Figure B1 depicts daily average flows for the three USGS sites.

Precipitation data were obtained from the U.S. Forest Service Ranger Station at Hoodsport, WA. In cases where several days passed without daily readings being taken, the total amount recorded on the day of reading was equally apportioned among the days where readings were not taken in order to provide an estimate of daily precipitation.

Flow Balance

Flow balances were developed to better understand the hydrologic characteristics in the study area and to help estimate bacteria loads. Flow values and balances are shown in Table B3 which lists sites in an upstream to downstream order, indicates the dynamic of the hydrograph at site Skok101, and indicates the dates that water quality samples were taken. The dynamic of the hydrograph was generalized by visual examination of the USGS continuous record (Figure B1 - USGS continuous record).

The difference between summed and measured flow values (residuals) are shown for Skok101 and PurBour in Table B3. These differences represent error in estimation techniques and losses or gains due to: rainfall runoff, unmeasured streams, groundwater, evaporation, and evapo-transpiration, and water withdrawals. Unmeasured inputs likely include Reichert Springs at RM 7.8 (Williams, Laramie, and Ames, 1975) and left bank streams between RM 5.8 to RM 7.8.

Seasonal patterns in the difference between summed and measured flows at Skok101 and PurBour were examined by plotting them over time and with rainfall. The differences were expressed as the summed flows divided by the observed flow, expressed as a percentage. Figures B2 and B3 suggest a seasonal component to the differences between observed and summed flows. Interaction with groundwater is likely a large component for the entire year. Where the summed value is less than the gaged value (i.e. ratio <100%), unmeasured flow from streams and/or groundwater likely increases river flow (December to June). When the summed flows are greater than the gaged values, river water is most likely lost through subsurface flow, recharge of groundwater, and/or water withdrawals (August to October).

Flow from Ikes and Rods creeks may carry part of Skokomish River flow during higher Skokomish River flows, as suggested by conductivity data for 11/15/99 and 12/13/99. As Skokomish River flows increase to some threshold, perhaps 4000 cfs, river water may enter the large wetland complex and then be routed through Ikes and Rods creeks. For the flow and FC loading balances, flows from Ikes and Rods were treated as independent flows. This treatment of the data would result in an artificial increase (estimated at 5 to 10%) of flow in the Skokomish as reflected at Skok106 on these two dates.

Flow values for NFSkok were taken from a gage about 2.4 miles downstream of the sample site. The gage site (RM 10.1) is best representative of flow entering the mainstem system and is likely a larger value than flow at the sample site (RM 12.5). Thus, FC loads calculated for the NFSkok may be overestimated (and thus conservative) due to the larger flow value.

The cumulative error from the varied flow estimates was not determined and remains an un-quantified factor in the flow balance. The accuracy of streamflow measurements was not determined but likely is in the range of +/- 5 to 20% of the true value. Flow estimates from rating curves or flow balances developed here exhibit acceptable precision when compared with measured flows. An estimated flow of the Skokomish mainstem from the sum of Skok101 and PurBour was within about 5% of a single flow measurement of the mainstem Skokomish at RM 2.8 on 9/15/99. The measured value was 340 cfs while the value from flow balance was 323 cfs. For the Skok101 site, over half of the flow balance estimates were +/- 10% of the gaged value. Another one-quarter of the estimates were within +/- 20% of the gaged value. For PurBour, flow balance estimates were consistently within 77%-79% of the three flows that were measured between September and January. For the Purdy/Weaver Creek basin, unmeasured flow inputs appeared to be relatively constant. Inputs were likely from the many springs originating from the southern valley wall and/or groundwater inputs.

Time of Travel

Time of travel in the mainstem Skokomish River was estimated in order to support bacteria loading estimates and improve flow balance calculations. Time of travel was estimated with two techniques using USGS flow data.

The first technique used stream measurement data from the three gaging stations in the study area. The mean velocity was regressed against flow and this relationship used to estimate stream velocity from flow on days when a flow balance was calculated. Stream, measurement data from 1994 or 1995 to present was used. Velocities from the SFSkok and Skok101 were averaged to produce a velocity used for the mainstem of the river, from Skok106 up to and including NFSkok and SFSkok. The velocity estimate from this method may be biased low because stream measurements made at gaging sites are representative of a relatively straight reach of river. Much of the lower mainstem river contains reaches with braided channels, riffles, pools, and eddies. These other characteristics likely result in a longer travel time than that derived from velocity data at gaging sites. The estimated travel times ranged from about 1.3 to 5.6 hours from SFSkok and NFSkok to Skok106.

The second method involved regressing USGS flow data from one site against time-shifted data from the downstream site. Two hydrologically active periods were selected to represent early winter and early summer flows. The downstream data set (Skok101) was time-shifted in 1-hour increments initially and then in additional 15-minute increments in order to obtain the best regression. The station pairs used were SFSkok and Skok101, and NFSkok and Skok101. Graphical examination of the time-shifted hydrograph versus the reference hydrograph showed agreement with the regression data. Lag times between hydrograph peaks were in the range of two-three hours for these pairs of stations for both the fall and summer periods examined. These lag times were then converted to velocity values. A three-hour lag for SFSkok to Skok101 yield a velocity of 2.2 mph; a travel time of 2.25 hours for NFSkok to Skok101 yield velocity of about 1.9 mph.

The record examined included a fall season period (11/13/99 to 12/13/99) and a spring season period (6/10/99 – 6/25/99). The range of flows at Skok101 for each of these periods was approximately 1500 – 5500 cfs for the fall period and 800 – 1300 cfs for the spring period. Extreme events were avoided due to possibility of increased error at higher stages. Error at the Skok101 gage site was estimated by USGS to be 30% or more at flows greater than 6000 cfs (KCM, 1997). The NFSkok flow accounts for about 10% of the flow at Skok101 whereas the SF accounts for about 60-70% of the flow at Skok101. That being the case, the NF hydrograph signature may not be discernable at Skok101 because of the magnitude of the SF flow. Regardless, the lag time estimate found was plausible (about two hours).

The velocity measurements from the two methods seemed comparable for the range of flows encountered. Velocities from the stream measurement method were used to determine travel times that might be used in estimating FC decay rates. Estimated velocity values were determined for each day for each of the three USGS-gaged sites. The values from the SFSkok and Skok101 were arithmetically averaged to produce a single velocity value to use for time of travel on that day. Travel times from SFSkok to Skok106 (about 6.9 miles) ranged from 1.3 hours during the 12/14/99 flood event to 5.6 hours during the mid-September low flow season. These travel times were considered quite short and so were not used for estimating FC decay rates in the study area.

The short travel times indicate that FC loads from tributaries showed up at downstream locations within a few hours. The order of sampling during each survey of the study period was generally from downstream to upstream sites, thus confounding the ability to accurately correlate upstream loading to downstream loads for individual days. With such short travel times, the decay, or die-off, of FC bacteria is probably negligible.

Table B1. Regressions used for evaluating probe and gage/tapedown records.

site	time period	use to predict (y from x)	Equation	R^2	n	note1	file	drift range
Lwr Weaver	12/3/99-1/28/99	gage from probe	y= 0.7851x+5.9857	0.96	6		weaver.xl	+/- 0.2'
Lwr Weaver	12/3/99-1/28/99	probe from gage	y= 1.2237-7.2111	0.96	6		weaver.xl	+/- 0.2'
Upr Purdy	2/18/99-1/28/00	gage from probe	y= 0.9702x+251.67	0.94	22		purdy.xls	+/- 0.8'
Upr Purdy	2/18/99-1/28/00	probe from gage	y= 0.9704x-244.15	0.94	22		purdy.xls	+/- 0.8'
Lwr Purdy	12/3/99-1/28/99	gage from probe	y= 0.5174x+28.977	0.99	6	excludes 12/13/99 event	purdy.xls	not evaluated (not used)
Lwr Purdy	12/3/99-1/28/99	probe from gage	y= 1.9171x-55.513	0.99	6	excludes 12/13/99 event	purdy.xls	not evaluated (not used)
Hunter	7/15/99-1/28/00	TD from probe	y= -0.9866x+13.212	1.00	17		hunter.xls	no drift
Hunter	7/15/99-1/28/00	probe from TD	y= -1.0127+13.381	1.00	17		hunter.xls	no drift
Vance	8/3/99-11/11/99	probe from TD	y= -1.0473x+16.483	1.00	10		vance.xls	no drift
Vance	12/3/99-1/28/00	probe from TD	y= -0.9848x+12.791	0.99	5		vance.xls	+/- 0.08'
Vance	8/3/99-11/11/99	TD from probe	y= -0.9534x+15.736	1.00	10		vance.xls	no drift
Vance	12/3/99-1/28/00	TD from probe	y= -1.0063x+12.979	0.99	5		vance.xls	+/- 0.08'

TD= tapedown (distance to water surface from a reference point on bridge or structure).
Transducer drift was not corrected for before regressing transducer vs reference point.
Review of transducer and reference point data suggests that several instruments exhibited drift.
Not correcting for drift results in weaker relationships between transducer and reference point regressions.
Field 'drift range' lists approximate range of instrument drift over time of deployment.

Table B2. Equations for estimating stage height and flows for the Skokmish TMDL study.

ref#	stream	dataset (x vs y)	equation	R^2	n	used to estimate flow?	comment	filename
1	Vance	calcgage vs Q	y = 110.24x^2 + 60.142x +	1.00	7	yes, conditional:	for USGS calcgage >0.0	skokrp12.xls
2	Vance	calcgage vs Q	y = 48.602x + 20.146	0.98	3	yes, conditional:	for USGS calc gage <=0.0	skokrp12.xls
3	Vance TDs	TD vs usgs gage	y = -0.9961x + 13.151	1.00	13	yes	good relationship	skokrp12.xls
4	Vance	SFSkokQ vs VanceQ	y = 0.00037321x^1.90225966	0.72	18	yes, conditional:	for SFSkokQ <= 850 cfs; for missing Vance Qs	Qbalance1.xls
5	Vance	SFSkokQ vs VanceQ	y = 0.5205x - 244.79	0.90	9	yes, conditional:	for SFSkokQ > 850 cfs; for missing Vance Qs	Qbalance1.xls
6	Swift	TD vs Q	y = 23.669x - 294.6	0.89	4	no	relationship nonsense; use avg Q=5.98	skokrp12.xls
7	Hunter	TD vs Q	y = -44.725x + 640.19	0.97	4	yes	good relationship	skokrp12.xls
8	TenAcre	gage vs Q	y = -2.7567x + 31.413	0.65	4	no	relationship nonsense; use avg Q=7.82	skokrp12.xls
9	Upr	uprTD vs upr or lwr Q	y = -44.131x + 439.51	0.84	7	no	approach not justified for study period?	skokrp12.xls
10	Upr Weaver	uprTD vs uprQ	y = 1.15*(-32.77x + 330.16)	0.74	3	no	estimate includes a 1.15 factor for measuremnt error (half of 30% difference between upper and lower flow measurements - suspect low-velocity Swoffer limitations)	skokrp12.xls
11	Upr Weaver(1.1)	uprTD vs lwrQ	y = -37.235x + 382.52	0.98	4	yes, conditional: second choice	use when LwrWeaver Q not available	skokrp12.xls
12	UprWeaver	time vs UprWeaverQ; 2/13/99-8/15/99	y = 0.0775x + 2854.7	0.89	11	yes, conditional: third choice	for est of Q for flow balance when Weaver Q missing	Qbalance2.xls
13	Lwr Weaver	lwrRP vs lwrQ	y = -29.388x + 390.53	0.98	4	yes, conditional: first choice	use this when present, otherwise use UprWeavr (1.1). RP may be tapedown or gage - one converted to the other	skokrp12.xls
14	Lwr Weaver	TD vs gage	y = -0.9836x + 19.499	1.00	12	no	for converting gage to TD	skokrp12.xls
15	Lwr Weaver	gage vs TD	y = -1.0142x + 19.804	1.00	12	yes	for converting TD to gage	skokrp12.xls
16	Weaver TDs	TDupr vs TDlwr	y = 1.4166x - 1.0364	0.91	13	no	good relationship	skokrp12.xls
17	UpPurdy	gage vs Q	y = 46.227x - 11667	0.90	4	yes	good relationship	skokrp12.xls

Table B2. Equations for estimating stage height and flows for the Skokmish TMDL study.

ref#	stream	dataset (x vs y)	equation	R^2	n	used to estimate flow?	comment	filename
18	LwrPurdy	LwrPurdysummdQ vs LwrPurdyQ measured	y = 1.36282x - 4.48376	1.00	3	yes: second choice	allows estimate of LwrPurdy from sum of upper-basin streams; this regression based on 3 non-storage/release measurements at LwrPurdy and upstream Qs	Qbalance2.xls
19	LwrPurdy	gage vs Q	y = 34.649x - 960.43	1.00	3	yes, conditional: first choice	based on non-storage/release conditions; generlaly when Skok101 Q <= 1200 cfs or LwrPurdy gage <= 31.40; dates 9/15-10/27, 11/3-11/6, and perhaps other later dates	skokrp12.xls
20	LwrPurdy	TD vs gage	y = -0.9918x + 37.275	1.00	12	yes	to estimate gage when no gage reading taken	skokrp12.xls
21	Ikes	TD vs Q	y = -28.45x + 331.29	1.00	5	yes, conditional:	for TD <= 11.47	
22	Ikes	TD vs Q	y = -14.995x + 176.87	1.00	3	yes, conditional:	for TD > 11.47	skokrp12.xls
23	Ikes	HunterQ vs IkesQ	y = 1.2333x - 139.59	0.96	8	yes, conditional:	for pre-8/99 flow estimates (primary estimator)	skokrp13.xls
24	Ikes	WeaverQ vs IkesQ	y = 4.0691x - 148.83	0.81	9	yes, conditional:	for pre-8/99 flow estimates (secondary estimator)	skokrp13.xls
25	Rods	TD vs Q	y = -29.509x + 306.8	0.92	3	yes, conditional:	for RP <= 8.1	skokrp12.xls
26	Rods	TD vs Q	y = 20149641655.7159*x^-	1.00	3	yes, conditional:	for RP > 8.1	skokrp12.xls
27	Rods	HunterQ vs RodsQ	y = 0.0000000020x^4.6154	0.96	7	yes, conditional:	for pre-8/99 flow estimates (primary estimator)	skokrp13.xls
28	Rods	WeaverQ vs RodsQ	y = 3.713x - 140.37	0.80	8	yes, conditional:	for pre-8/99 flow estimates (secondary estimator)	skokrp13.xls
29	NoName1	2 measurements	-	-	-	-	use avg Q = 2.36 cfs	skokrp12.xls
30	UprPurdy	Hunter vs UprPurdy	y = 0.0752x + 28.33	0.17	6	yes, one day only:	for 1/30/00 only	Qbalance2.xls

Q = flow
TD = tapedown (distance from water surface to fixed reference point)
RP = reference point for tapedown measurements (some sites had more than one reference point)

Table B3. Skokomish River flow balances for study period.

			South Fork/North Fork/mainstem to Hwy 101 bridge							Purdy/Weaver Basin	
		RM -->	SF 3.15	SF 0.90	10.10	8.70	6.30	-	5.80	1.90	1.50
		Station -->	**SFSkok**	**Vance**	**NFSkok**	**Swift**	**Hunter**	**Skok101 residual**	**Skok101**	**Weaver**	**WeavrLow**
Date of Observation	**survey type**	**hydrograph**	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
1/12/99	wq	flat	678.0	90.7	121.0	6.0	162.0	62.3	1120.0	51.4	
1/13/99	wq	flat	652.0	84.2	121.0	6.0	162.0	44.8	1070.0	51.3	
2/16/99	wq	rising late	1730.0	562.0	350.0	6.0	185.8	-333.7	2500.0	47.0	
2/17/99	flow	peak	1880.0	679.4	419.0	6.0	206.0	269.6	3460.0	49.6	
2/18/99	flow	falling early	1520.0	546.4	349.0	6.0	186.0	-47.3	2560.0	48.5	
3/15/99	wq	falling early	1510.0	586.7	271.0	6.0	208.2	698.2	3280.0	50.8	
4/8/99	flow	flat	615.0	181.5	385.0	6.0	139.0	253.5	1580.0	44.7	
4/12/99	wq	flat	603.0	179.7	402.0	6.0	138.8	240.5	1570.0	44.1	
4/20/99	flow	falling early	857.0	201.3	114.0	6.0	161.0	220.8	1560.0	43.8	
5/10/99	wq	flat	517.0	81.1	93.0	6.0	138.8	164.2	1000.0	39.6	
5/13/99	flow	flat	531.0	97.4	92.0	6.0	137.0	129.6	993.0	42.0	
5/17/99	flow	rising early	581.0	67.6	102.0	6.0	138.8	154.6	1050.0	41.8	
6/14/99	wq	rising late	831.0	32.3	82.0	6.0	147.8	41.0	1140.0	41.5	
6/17/99	flow	falling early	740.0	36.0	81.0	6.0	148.0	39.1	1050.0	39.3	
7/12/99	wq	peak	524.0	16.9	73.0	6.0	128.5	55.6	804.0	38.1	
7/14/99	flow	falling early	483.0	16.4	73.0	6.0	125.9	46.7	751.0	37.2	
7/15/99	flow	falling late	420.0	36.5	73.0	6.0	123.4	16.1	675.0	37.0	
8/9/99	wq	falling late	257.0	10.3	68.0	6.0	115.9	-27.2	430.0	35.9	
8/12/99	flow	flat	243.0	8.3	71.0	8.7	114.6	-54.6	391.0	35.5	
9/13/99	wq	flat	118.0	1.5	66.0	7.3	109.0	-53.8	248.0		38.8
9/14/99	flow	flat	116.0	1.4	67.0	6.0	108.9	-58.3	241.0		36.6
9/15/99	flow	flat	116.0	1.4	67.0	6.0	109.0	-57.4	242.0		34.5
10/12/99	wq	falling late/flat	172.0	13.3	68.0	4.2	115.0	-77.4	295.0		44.1
11/8/99	wq	falling late	1070.0	308.9	153.0	6.0	178.9	103.3	1820.0		57.9
11/15/99	wq	falling late	1240.0	470.4	262.0	3.8	193.8	80.0	2250.0		58.5
11/18/99	flow	falling late	815.0	232.5	184.0	6.0	165.8	66.6	1470.0		50.5
11/29/99	wq	falling late	1250.0	492.9	276.0	6.0	188.2	-163.1	2050.0		54.6
12/13/99	wq	falling early	2230.0	1009.7	407.0	6.0	244.7	462.6	4360.0		84.1
12/14/99	flow	falling late	1980.0	1088.1	423.0	6.0	231.4	-68.5	3660.0		62.5
12/27/99	wq	falling late	733.0	90.4	164.0	6.0	155.8	40.8	1190.0		50.9
1/10/00	flow	falling early	788.0	180.1	189.0	6.0	166.7	120.3	1450.0		46.5
1/11/00	wq	falling late	694.0	145.3	179.0	6.0	160.0	105.7	1290.0		45.1
1/24/00	wq	falling late	755.0	208.0	213.0	6.0	165.6	102.4	1450.0		45.6
1/30/00	flow	falling late	553.0	110.7	165.0	6.0	146.9	28.5	1010.0		39.6

Table B3. Skokomish River flow balances for study period.

			Purdy/Weaver Basin				Lower river to Hwy 106 bridge			
		RM -->	1.90	1.80	-	0.60	2.50	2.30	2.10	2.10
		Station -->	**TenAcre**	**UpPurdy**	**PurBour residual**	**PurBour**	**Ikes**	**Rods**	**NoName1**	**Skok106b**
Date of Observation	**survey type**	**hydrograph**	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
1/12/99	wq	flat	7.8	52.0	32.9	144.1	60.2	31.5	2.4	1358.2
1/13/99	wq	flat	7.8	52.0	32.9	144.0	60.2	31.5	2.4	1308.1
2/16/99	wq	rising late	7.8	59.7	34.0	148.5	89.5	59.3	2.4	2799.8
2/17/99	flow	peak	7.8	59.7	34.9	152.0	114.5	95.6	2.4	3824.5
2/18/99	flow	falling early	7.8	59.7	34.5	150.5	89.8	59.7	2.4	2862.3
3/15/99	wq	falling early	7.8	62.9	36.4	157.8	117.1	100.3	2.4	3657.6
4/8/99	flow	flat	5.7	51.6	29.8	131.9	31.8	15.6	2.4	1761.7
4/12/99	wq	flat	9.4	50.9	30.6	134.9	31.6	15.5	2.4	1754.3
4/20/99	flow	falling early	7.8	46.8	28.6	127.0	58.9	30.6	2.4	1778.9
5/10/99	wq	flat	9.6	42.5	26.4	118.1	31.6	15.5	2.4	1167.5
5/13/99	flow	flat	10.0	42.9	27.4	122.3	29.4	14.6	2.4	1161.6
5/17/99	flow	rising early	7.8	43.5	26.8	119.9	31.6	15.4	2.4	1219.3
6/14/99	wq	rising late	9.5	34.4	24.2	109.5	42.7	20.6	2.4	1315.1
6/17/99	flow	falling early	7.8	32.6	22.3	102.0	42.9	20.8	2.4	1218.1
7/12/99	wq	peak	9.6	28.4	21.1	97.2	18.9	10.8	2.4	933.4
7/14/99	flow	falling early	7.8	28.1	20.1	93.2	15.7	9.9	2.4	872.1
7/15/99	flow	falling late	9.6	28.4	20.7	95.7	12.6	9.0	2.4	794.7
8/9/99	wq	falling late	9.5	24.9	19.2	89.5	9.5	6.7	2.4	538.0
8/12/99	flow	flat	8.1	24.1	18.3	85.9	1.7	6.4	2.4	487.3
9/13/99	wq	flat	8.1	21.7	18.6	87.1	1.4	5.1	2.3	343.8
9/14/99	flow	flat	7.5	22.0	17.7	83.8	-5.3	5.0	2.4	326.9
9/15/99	flow	flat	7.8	22.0	17.1	81.4	-5.2	5.1	2.4	325.6
10/12/99	wq	falling late/flat	8.2	20.1	19.8	92.2	4.4	6.5	2.5	400.6
11/8/99	wq	falling late	7.8	19.7	24.2	109.6	73.6	59.1	2.4	2064.7
11/15/99	wq	falling late	7.8	21.4	25.0	112.6	84.1	75.4	2.4	2524.4
11/18/99	flow	falling late	7.8	34.5	26.7	119.6	64.9	35.1	2.4	1692.0
11/29/99	wq	falling late	7.8	20.9	23.5	106.9	87.2	87.9	2.4	2334.3
12/13/99	wq	falling early	7.8	44.3	41.3	177.5	176.3	157.8	2.4	4874.0
12/14/99	flow	falling late	7.8	48.1	35.3	153.8	145.8	163.4	2.4	4125.3
12/27/99	wq	falling late	7.8	37.5	27.9	124.2	48.2	17.4	2.4	1382.2
1/10/00	flow	falling early	7.8	34.8	25.5	114.6	66.0	36.0	2.4	1668.9
1/11/00	wq	falling late	7.8	37.0	25.8	115.7	52.5	23.9	2.4	1484.4
1/24/00	wq	falling late	7.8	52.8	31.2	137.4	59.9	30.0	2.4	1679.7
1/30/00	flow	falling late	7.8	39.4	24.7	111.6	41.5	20.1	2.4	1185.5

Figure B1. Skokomish River flow during the 1999-2000 TMDL study period.

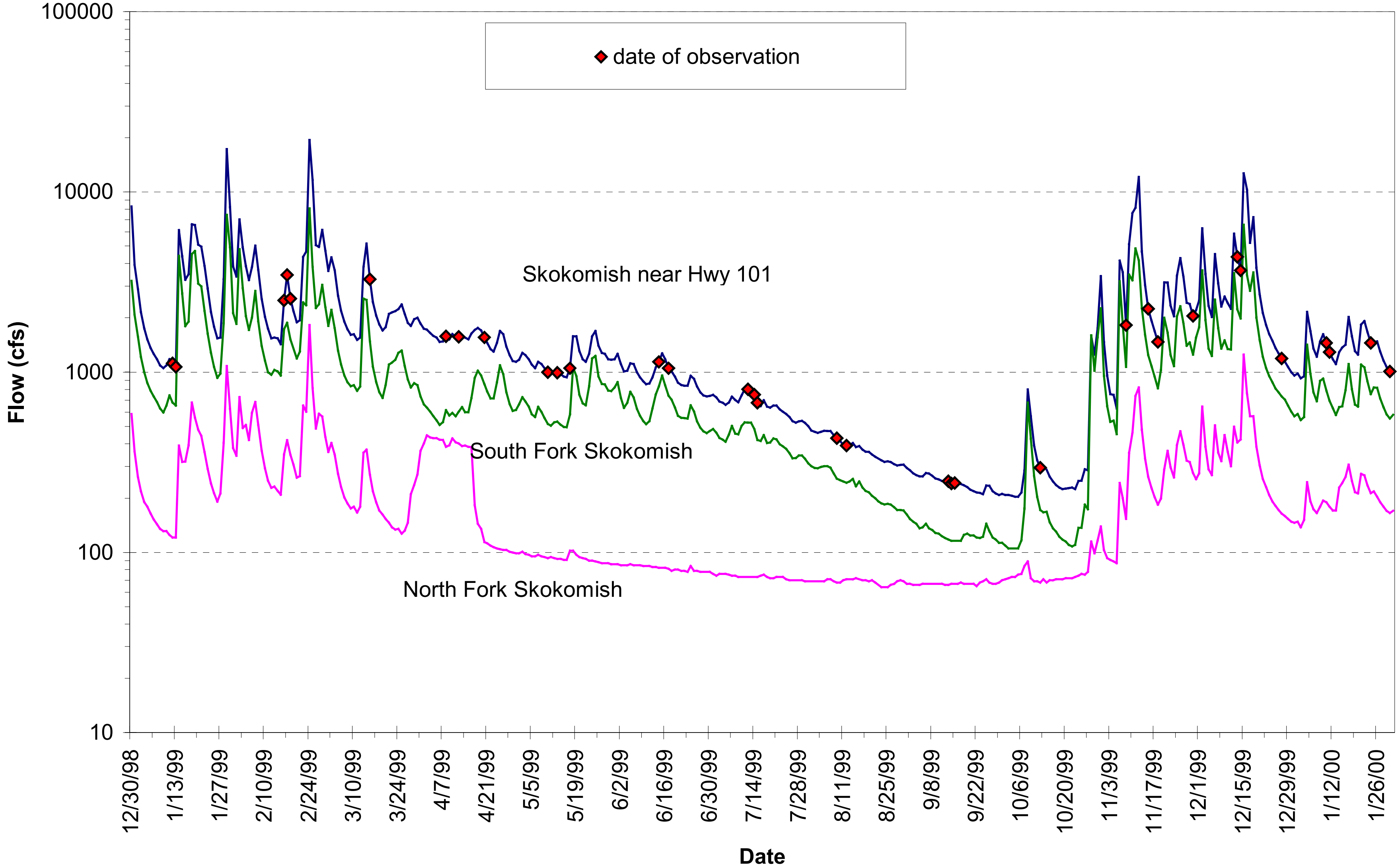


Figure B2. Site Skok101 summed flow as percentage of observed flow.

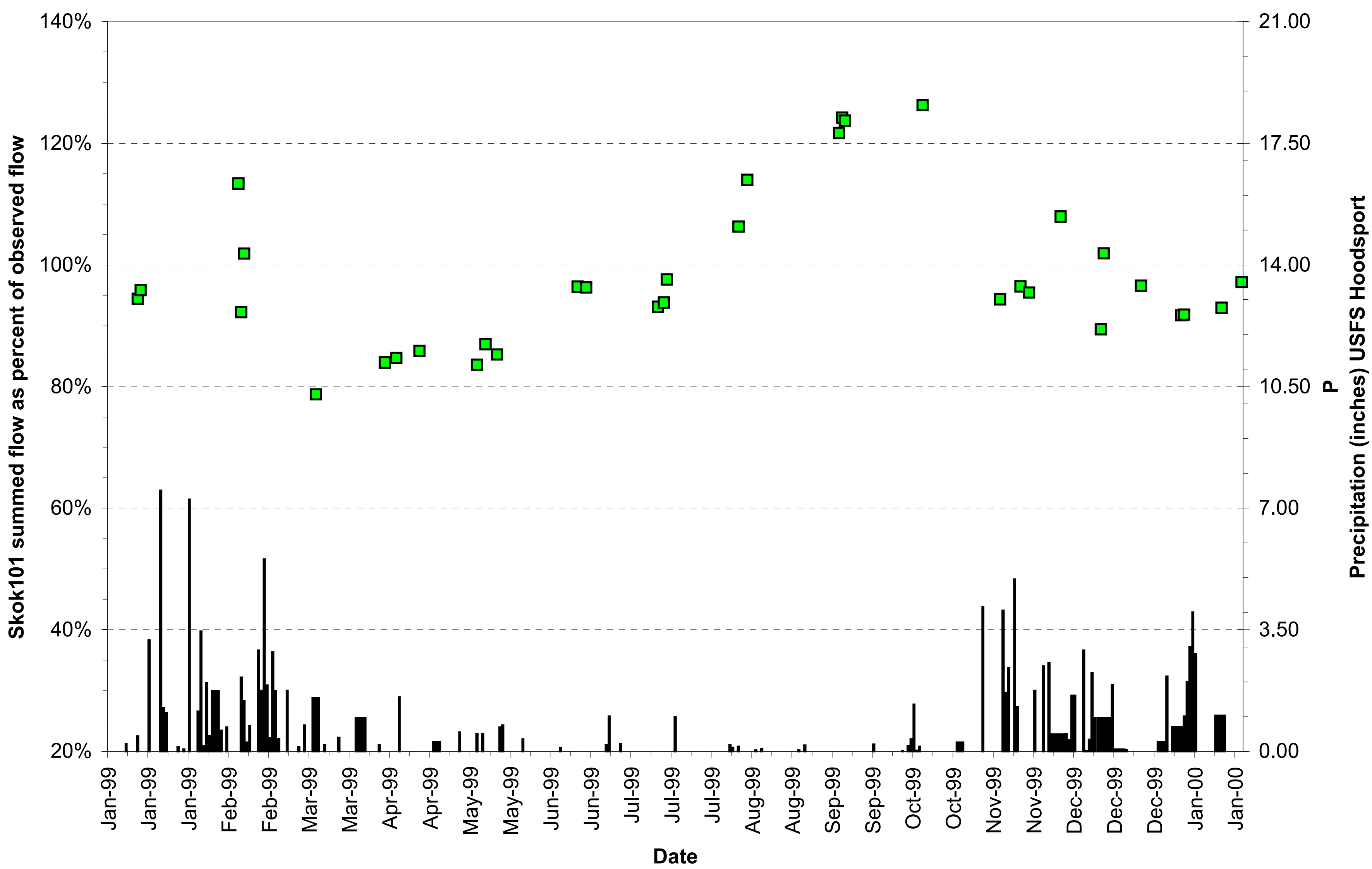
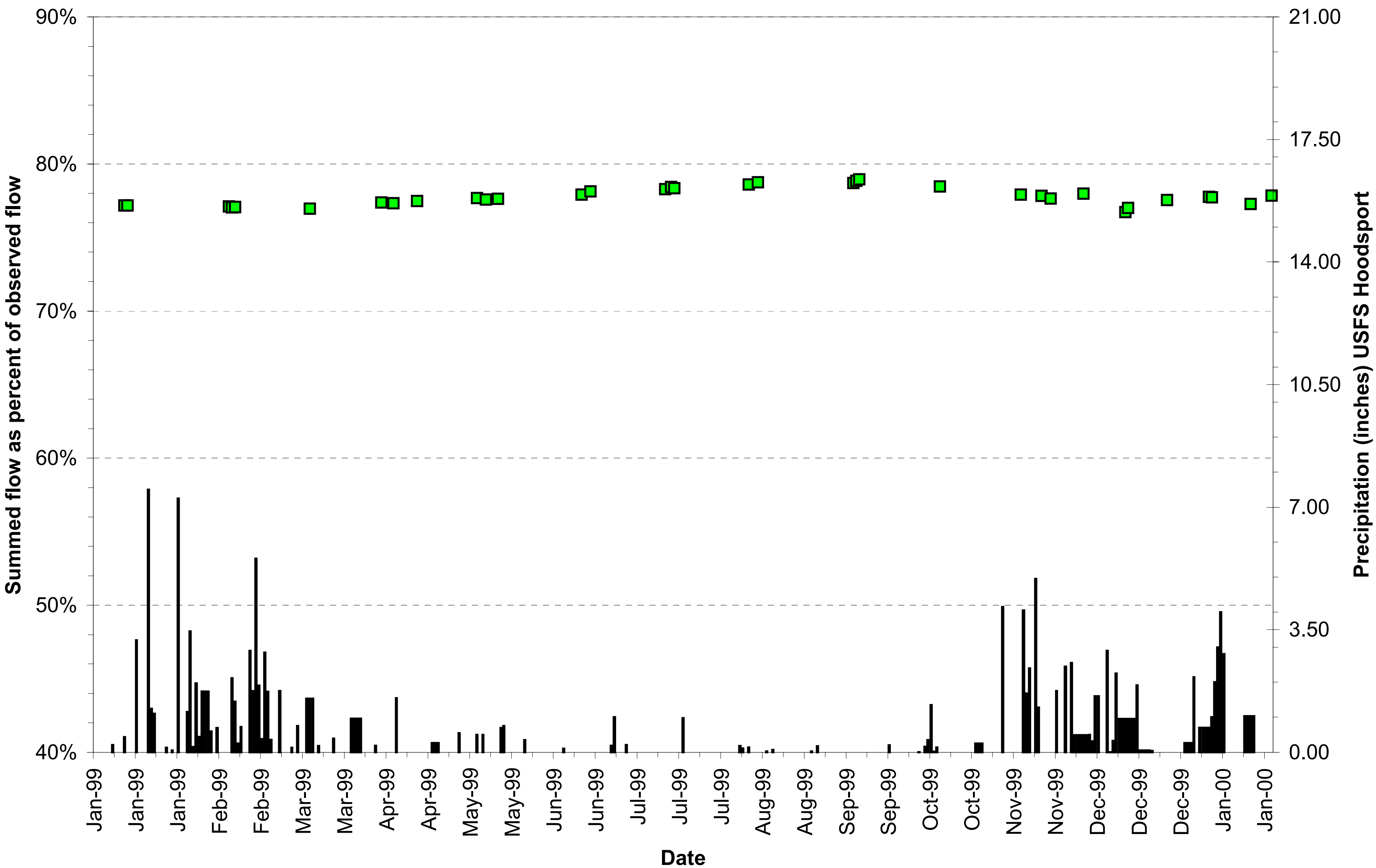


Figure B3. Site PurBour summed flow as percentage of observed flow.



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Appendix C1. Data qualifiers and field names.

qualifier	description
U	not detected at the given detection limit
J	result is an estimate at the given detection limit
e	qualified as estimate due to possible sample aeration at high flow
m	parameter or flow was measured in-situ
a	flow is daily average from USGS trapezoidal method or Ecology 1-hour moving average from transducer record
t	flow is instantaneous value from USGS or Ecology transducer (closest time value used)
r	flow from reference point measurement (tapedown or gage)
i	flow from interbasin regression (e.g Hunter vs Ikes, Vance vs SFSkok)
s	flow is sum of upstream values
o	flow from other methods such as averaging, multiple of a previous day's flow, regression, seasonal value, etc.
th	temperature from Hydrolab thermistor
to	temperature from Orion 135 thermistor
ta	temperature from alcohol thermometer
ch	conductivity from Hydrolab probe
co	conductivity from Orion 135 probe

field name	units	description
Staname1		abbreviated station name
Date		date
Time		time
Sample type		type of sample: regular, field replicate, or storm event
Sample study		study data collected for: tmdl or emts (Ecology ambient monitoring)
10dlabID		10 digit lab ID number
Field rep pair L		number assigned to pair of field replicates of lab samples
FCmpn	#/100mL	Fecal Coliform with the Most Probable Number (MPN) method
Qual FCmpn		qualifier for FCmpn
Ecoli	#/100mL	E. coli using the MPN method
Qual Ecoli		qualifier for Ecoli
FCmf	#/100mL	Fecal Coliform with the membrane filter method
Qual FCmf		qualifier for FCmf
TSS	mg/L	Total Suspended Solids
Qual TSS		qualifier for FCmpn
CondL	umho/cm	sample conductivity determined by laboratory
Qual condL		qualifier for condL
Temp	degrees Celsius	in-situ water temperature
Qual temp		qualifier for temp
Temp inst		temperature instrument used
CondF	umho/cm	in-situ water conductivity
Qual condF		qualifier for condF
Cond inst		field conductivity instrument used
DO	mg/L	dissolved oxygen
Qual DO		qualifier for DO
DO %sat		dissolved oxygen percent saturation; uses Streeter-Phelps
Fieldrep pair F		number assigned to pair of replicates of field measurements
CondC	umho/cm	conductivity; either lab or field determined
Qfinal	cfs	flow
Qual Qfinal		qualifier for flow
Sort1		sorting order

Appendix C2. Skokomish TMDL Water Quality Data.

Staname1	Date	Time	10dlabID	field rep pair L	FCmpn	qual FCmpn	Ecoli	qual Ecoli	FCmf	qual FCmf	TSS	qual TSS	condL	qual condL	temp	qual temp	temp inst	condF	qual condF	cond inst	DO	qual DO	DO %sat	fieldrep pair F	CondC	Qfinal	Qual Qfinal
SFSkok	01/13/99	11:15	1999028141		4.5		4.5				1		54.7		5.3		th	44.8		ch					54.7	652	a
SFSkok	02/16/99	13:00	1999079607		7.8		7.8		3		47		47.3		4.8		th	46.1		ch	12.8		100%		47.3	1730	a
SFSkok	03/15/99	13:45	1999119607		1.8	U	1.8	U	1	U	26		45.9		5.3		th	40.2		ch					45.9	1510	a
SFSkok	04/12/99	14:25	1999159607		1.8	U	1.8	U	1	U	1		52.8		7.2		th	48.0		ch	12.3		102%		52.8	603	a
SFSkok	05/10/99	13:20	1999199607		1.8	U	1.8	U	1	U	1	U	53.7		8.1		to	50.0		co	12.2		103%		53.7	517	a
SFSkok	06/14/99	13:05	1999249607		2.0		2.0		1	U	4		46.1		9.7		th	32.4		ch					46.1	831	a
SFSkok	07/12/99	14:25	1999289607		1.8	U	1.8	U	1	U	1	U	50.9		12.8		th	37.6		ch					50.9	524	a
SFSkok	08/09/99	15:35	1999329607		2.0		1.8	U	2		1	U	61.1		14.5		ta								61.1	257	a
SFSkok	09/13/99	15:30	1999379607		1.8	U	1.8	U	1		1	U			14.4		to	66.4		co					66.4	118	a
SFSkok	10/12/99	8:05	1999419607		2.0		2.0		3		1	U			9.3		to	62.5		co					62.5	172	a
SFSkok	11/15/99	13:50	1999469607		1.8		1.8		3		21				8.2		to	47.9		co					47.9	1240	a
SFSkok	12/13/99	12:55	1999509607		2.0		2.0		1		41				5.6		to	41.5		co					41.5	2230	a
SFSkok	01/11/00	13:50	2000029607		2.0		2.0		1		1				3.6		to	48.6		co					48.6	694	a
NFSkok	02/16/99	14:35	1999079609		1.8	U	1.8	U	1		6		43.3		5.7		th	42.8		ch	12.2		97%		43.3	350	a
NFSkok	03/15/99	15:33	1999119609		2.0		2.0		1	U	2		44.4		6.3		th	38.2		ch	12.5		101%		44.4	271	a
NFSkok	04/12/99	16:34	1999159609		1.8	U	1.8	U	1	U	2		54.5		7.3		th	62.0		ch	12.1		100%		54.5	402	a
NFSkok	05/10/99	15:20	1999199609	5	1.8	U	1.8	U	1	U	1	U	57.1		9.2		to	54.8		co	11.6		101%	3	57.1	93.0	a
NFSkok	05/10/99	15:30	1999199613	5	1.8	U	1.8	U	1	U	1	U	57.3		9.2		to	59.0		co	11.6		101%	3	57.3		
NFSkok	06/14/99	15:42	1999249609		2.0		2.0		1		1	U	59.8		11.9		th	46.9		ch	11.0		102%		59.8	82.0	a
NFSkok	07/12/99	17:40	1999289609		2.0		2.0		1		1	U	61.2		12.3		th	47.5		ch	10.6		99%		61.2	73.0	a
NFSkok	08/09/99	13:35	1999329609		7.8		7.8		5		1	U	61.8		11.4		ta				11.0		101%		61.8	68.0	a
NFSkok	09/13/99	7:40	1999379609		3.6		3.6		4		1	U			9.3		to	58.4		co	10.9		95%		58.4	66.0	a
NFSkok	10/12/99	14:45	1999419609		2.0		2.0		2		1	U			10.3		to	58.0		co					58.0	68.0	a
NFSkok	11/15/99	7:35	1999469609		2.0		2.0		1		2				9.1		to	50.1		co					50.1	262	a
NFSkok	12/13/99	7:15	1999509609		6.8		6.8		3		3				6.8		to	43.0		co					43.0	407	a
NFSkok	01/11/00	8:20	2000029609		1.8		1.8	U	1		1	U			5.1		to	49.8		co					49.8	179	a
MidSkok	01/13/99	10:43	1999028139		2.0		2.0				2		57.1		5.9		th	45.8		ch					57.1	857	s
MidSkok	02/16/99	13:35	1999079608		7.8		7.8		7		42		48.6		5.4		th	47.2		ch	12.3		97%		48.6	2640	s
MidSkok	03/15/99	14:16	1999119608		4.5		4.5		1		22		47.2		6.0		th	40.9		ch	11.6		93%		47.2	2370	s
MidSkok	04/12/99	15:18	1999159608		1.8	U	1.8	U	1	U	2		54.5		8.4		th	62.0		ch	11.9		101%		54.5	1180	s
MidSkok	05/10/99	14:10	1999199608		2.0		2.0		1	U	1		56.3		9.1		to	55.3		co	11.8		102%		56.3	691	s
MidSkok	06/14/99	14:00	1999249608		2.0		2.0		1		4		49.6		11.5		th	36.2		ch					49.6	945	s
MidSkok	07/12/99	15:43	1999289608		1.8	U	1.8	U	1	U	1	U	54.5		14.3		th	40.8		ch					54.5	614	s
MidSkok	08/09/99	16:25	1999329608	14	6.1		4.0		1	U	1	U	62.8		15.7		ta				10.4		104%	2	62.8	335	s
MidSkok	08/09/99	16:25	1999329614	14	13		7.8		1		1	U	62.7								10.2			2	62.7		
MidSkok	09/13/99	17:15	1999379608		2.0		1.8	U	1		1	U			14.7		to	62.4		co	10.3		101%		62.4	186	s
MidSkok	10/12/99	8:48	1999419608		11		11		4		1	U			9.7		to	62.8		co					62.8	253	s

Appendix C2. Skokomish TMDL Water Quality Data.

Staname1	Date	Time	10dlabID	field rep pair L	FCmpn	qual FCmpn	Ecoli	qual Ecoli	FCmf	qual FCmf	TSS	qual TSS	condL	qual condL	temp	qual temp	temp inst	condF	qual condF	cond inst	DO	qual DO	DO %sat	fieldrep pair F	CondC	Qfinal	Qual Qfinal
MidSkok	11/15/99	13:00	1999469608		4.5		2.0		3	J	18				8.6		to	49.8		co					49.8	1970	s
MidSkok	12/13/99	13:45	1999509608	18	2.0		2.0		1	U	51				6.1		to	43.1		co					43.1	3650	s
MidSkok	12/13/99	13:45	1999509613	18	1.8		1.8	U	2		53																
MidSkok	01/11/00	14:50	2000029608		2.0		2.0		1		1				4.1		to	50.1		co					50.1	1020	s
Skok101	01/13/99	10:10	1999028135		13		7.8				3	J	61.5		6.5		th	51.4		ch					61.5	1070	a
Skok101	01/21/99	14:05							3		8				5.3			61.0			11.7		92%		61.0	4970	a
Skok101	02/16/99	15:50	1999079610		13		13		7		34		50.8		5.8		th	49.8		ch	12.0		96%		50.8	2500	a
Skok101	02/21/99	13:45							5		30				4.9			37.0			11.8		92%		37.0	1940	a
Skok101	03/15/99	16:44	1999119610		1.8	U	1.8	U	1		23		51.0		6.4		th	46.4		ch					51.0	3280	a
Skok101	03/31/99	15:05							1		6				5.3			54.0			12.0		95%		54.0	1860	a
Skok101	04/12/99	17:25	1999159610		1.8	U	1.8	U	1	U	2		58.5		9.1		th	80.0		ch	11.4		99%		58.5	1570	a
Skok101	04/21/99	15:40							4		4				7.1			55.0			11.6		96%		55.0	1450	a
Skok101	05/10/99	16:40	1999199610		4.0		4.0		1		2		68.3		10.5		to	60.5		co	11.2		100%		68.3	1000	a
Skok101	05/11/99	14:30							30		14				7.7			48.0			11.8		99%		48.0	982	a
Skok101	05/17/99	11:35	1999209600		130		130		150		4		60.1												60.1	1050	a
Skok101	05/17/99	18:50	1999209601		110		110		85		5		59.3												59.3	1050	a
Skok101	06/14/99	17:10	1999249610	9	14		14		6		6		55.1		13.0		th	42.1		ch				5	55.1	1140	a
Skok101	06/14/99	17:10	1999249614	9	13		13		12		5		54.5											5	54.5		
Skok101	06/21/99	13:55							12		2				8.1			60.0			11.1		94%		60.0	849	a
Skok101	07/12/99	18:45	1999289610		13		13		3		2		60.9		14.2		th	47.4		ch	10.2		99%		60.9	804	a
Skok101	07/21/99	13:05							27		2				10.1			55.0			10.3		91%		55.0	654	a
Skok101	08/09/99	8:40	1999329610	12	33		33		18		1		68.7		11.7		ta				10.2		94%	6	68.7	430	a
Skok101	08/09/99	8:40	1999329612	12	31		31		24		1		68.7								10.5			6	68.7		
Skok101	08/21/99	13:40							2		1				10.3			58.0			10.0		89%		58.0	339	a
Skok101	09/13/99	8:45	1999379610		17		17		11		1	U			9.6		to	68.9		co	10.2		89%		68.9	248	a
Skok101	09/21/99	15:45							1		1				8.4			60.0			11.5		98%		60.0	219	a
Skok101	10/12/99	13:45	1999419610		33		17		5		1	U			10.1		to	68.0		co	10.5		93%		68.0	295	a
Skok101	10/21/99	13:45													7.0			70.0			10.5		86%		70.0	227	a
Skok101	11/11/99	14:00							6		11				7.0			54.0			10.7		88%		54.0	8160	a
Skok101	11/15/99	8:25	1999469610		4.5		4.5		10	J	22				8.6		to	52.2		co	10.9		94%		52.2	2250	a
Skok101	12/11/99	13:30							8		28				5.0			46.0			11.7		92%		46.0	2250	a
Skok101	12/13/99	8:10	1999509610		4.5		4.5		1		56				5.9		to	44.0		co	11.9	e	96%		44.0	4360	a
Skok101	01/11/00	9:15	2000029610		13		13		5		3				5.3		to	54.6		co	11.5		91%		54.6	1290	a
Skok101	01/21/00	13:10													5.0			50.0			11.8		92%		50.0	1830	a
SkokChic	01/12/99	10:07	1999028131		4.5		4.5				4		63.9		6.9		th	59.6		ch					63.9	1320	s
SkokChic	02/16/99	10:05	1999079601		23		23		10		24		55.7		5.8		th	54.2		ch	11.5		92%		55.7	2740	s
SkokChic	03/15/99	10:10	1999119601	2	7.8		7.8		6		22		51.2		5.7		th	45.3		ch	12.0		96%	7	51.2	3550	s

Appendix C2. Skokomish TMDL Water Quality Data.

Staname1	Date	Time	10dlabID	field rep pair L	FCmpn	qual FCmpn	Ecoli	qual Ecoli	FCmf	qual FCmf	TSS	qual TSS	condL	qual condL	temp	qual temp	temp inst	condF	qual condF	cond inst	DO	qual DO	DO %sat	fieldrep pair F	CondC	Qfinal	Qual Qfinal
SkokChic	03/15/99	10:15	1999119612	2	2.0		2.0		2		24		51.4								12.0			7	51.4		
SkokChic	04/12/99	10:25	1999159601		4.5		4.5		5		2		61.1		7.1		th	46.0		ch	11.3		93%		61.1	1740	s
SkokChic	05/10/99	10:00	1999199601		6.8		6.8		10		2		64.4		7.2		to	58.5		co	11.3		94%		64.4	1150	s
SkokChic	06/14/99	9:47	1999249601		22		22		13		4		58.8					46.2		ch					58.8	1290	s
SkokChic	07/12/99	9:47	1999289601	11	49		49		22		3		64.6		11.5		th	50.5		ch	9.5		87%		64.6	920	s
SkokChic	07/12/99	9:47	1999289613	11	33		33		23		2		65.5												65.5		
SkokChic	08/09/99	10:00	1999329601		240		240		23		1	U	74.1		12.3		ta				9.7		90%		74.1	529	s
SkokChic	09/13/99	10:45	1999379601		13		13		49		1				9.9		to	74.2		co	10.1		89%		74.2	337	s
SkokChic	10/12/99	10:25	1999419601		33		33		21		1				9.4		to	73.4		co	9.9		86%		73.4	392	s
SkokChic	11/15/99	10:00	1999469601		22		22		12	J	16				8.7		to	54.3		co					54.3	2450	s
SkokChic	12/13/99	9:35	1999509601		33		23		16		37				5.9		to	44.9		co					44.9	4710	s
SkokChic	01/11/00	10:45	2000029601		7.8		7.8		9		2				5.0		to	57.2		co	13.6		106%		57.2	1460	s
Skok106b	01/12/99	9:28	1999028130		11		11				3		72.2		7.0		th	68.9		ch					72.2	1360	s
Skok106b	02/16/99	9:35	1999079600		33		33		16		21	J	64.7		5.9		th	62.4		ch	11.1		89%		64.7	2800	s
Skok106b	03/15/99	9:29	1999119600		33		33		34		23		52.8		5.7		th	48.0		ch	11.8		94%		52.8	3660	s
Skok106b	04/12/99	9:57	1999159600		11		11		6		2		68.1		6.9		th	50.0		ch	11.0		90%		68.1	1750	s
Skok106b	05/10/99	9:00	1999199600		7.8		7.8		9		2		73.2		6.8		to	67.2		co	11.1		91%		73.2	1170	s
Skok106b	06/14/99	9:35	1999249600		23		23		18		4		65.1		9.1		th	50.2		ch	10.8		94%		65.1	1320	s
Skok106b	07/12/99	9:10	1999289600		33		33		20		1		72.2		10.6		th	58.6		ch					72.2	933	s
Skok106b	08/09/99	9:45	1999329600		49		49		26		1	U	82.1		11.2		ta				9.6		87%		82.1	538	s
Skok106b	09/13/99	9:55	1999379612		540		562		93		1				9.5		to	85.0		co	9.5		83%		85.0	344	s
Skok106b	10/12/99	9:42	1999419600		70		70		32		1				9.2		to	82.8		co	9.9		86%		82.8	401	s
Skok106b	11/08/99	9:45													8.7		to	68.8		co					68.8	2060	s
Skok106b	11/15/99	9:30	1999469600		17		17		7	J	17				8.6		to	55.0		co	10.8		92%		55.0	2520	s
Skok106b	12/13/99	9:20	1999509600		110		49		260	J	14				5.4		to	51.9		co	10.8		86%		51.9	4870	s
Skok106b	01/11/00	10:20	2000029600		23		23		9		2				5.4		to	72.5		co	12.0		95%		72.5	1480	s
Skok106c	09/13/99	9:35	1999379600		110		110		130		2		78.5		10.2		to	76.9		co	9.7		86%		78.5	344	s
Skok106c	10/12/99	9:30	1999419612		130		130		43		1				9.5		to	72.5		co	10.2		89%		72.5	401	s
Skok106c	11/08/99	9:25	1999459612						21		16				8.9		to	55.1		co					55.1	2060	s
Skok106c	11/15/99	8:55	1999469612		7.8		7.8		11		21				8.7		to	54.3		co	10.7		92%		54.3	2520	s
Skok106c	11/29/99	9:40	1999489612						3		9				7.2		to	53.7		co					53.7	2330	s
Skok106c	12/13/99	8:45	1999509612		13		13		24		46				5.4		to	45.3		co	11.9	e	94%		45.3	4870	s
Skok106c	12/27/99	10:05	1999529612						8		4				5.9		to	59.0		co					59.0	1380	s
Skok106c	01/11/00	9:35	2000029612		18		18	U	12		3				5.0		to	57.4		co	11.3		88%		57.4	1480	s
Skok106c	01/24/00	10:00	2000049612						11		3				5.4		to	56.3		co					56.3	1680	s
Vance	01/12/99	11:52	1999028138		2.0		2.0				1		61.3		7.7		th	45.1		ch					61.3	90.7	i
Vance	02/16/99	11:55	1999079606		11		11		7		144		48.7		6.0		th	47.8		ch	11.9		96%		48.7	562	r

Appendix C2. Skokomish TMDL Water Quality Data.

Staname1	Date	Time	10dlabID	field rep pair L	FCmpn	qual FCmpn	Ecoli	qual Ecoli	FCmf	qual FCmf	TSS	qual TSS	condL	qual condL	temp	qual temp	temp inst	condF	qual condF	cond inst	DO	qual DO	DO %sat	fieldrep pair F	CondC	Qfinal	Qual Qfinal
Vance	03/15/99	11:56	1999119606		1.8	U	1.8	U	2		11		48.6		6.5		th	43.0		ch					48.6	587	r
Vance	04/12/99	12:42	1999159606		4.5		4.5		1	U	1	U	54.8		8.1		th	48.0		ch	11.9		101%		54.8	180	r
Vance	05/10/99	12:05	1999199606		1.8		1.8		2		1	U	59.1		9.1		to	57.6		co	11.9		103%		59.1	81.1	r
Vance	06/14/99	11:30	1999249606	8	4.5		4.5		2		1		66.7		12.0		th	53.7		ch	10.9		101%	15	66.7	32.3	r
Vance	06/14/99	11:30	1999249613	8	4.5		4.5		4		1	U	66.5								10.9			15	66.5		
Vance	07/12/99	11:43	1999289606		22		22		7		1	U	71.7		13.1		th	58.0		ch					71.7	16.9	r
Vance	08/09/99	12:25	1999329606		130		130		72		1	U	74.4		13.0		ta				10.9		103%		74.4	10.3	a
Vance	09/13/99	13:50	1999379606		33		33		20		1	U			12.2		to	71.2		co	10.9		102%		71.2	1.5	a
Vance	10/12/99	12:20	1999419606		13		13		21		1	U			9.9		to	72.0		co	11.2		99%		72.0	13.3	a
Vance	11/08/99	11:20	1999459606						5		4				9.3		to	54.8		co					54.8	309	a
Vance	11/15/99	12:10	1999469606		7.8		4.5		3		17				9.0		to	53.2		co	11.0		95%		53.2	470	r
Vance	11/29/99	12:05	1999489606						1	U	6				7.8		to	51.8		co					51.8	493	r
Vance	12/13/99	11:35	1999509606		2.0		2.0		2		28				6.8		to	45.7		co	12.0		98%		45.7	1010	a
Vance	12/27/99	14:15	1999529606						1		1	U			7.1		to	57.1		co					57.1	90.4	a
Vance	01/11/00	12:20	2000029606	20	7.8		7.8		15		1				5.2		to	51.8		co	13.7		108%	11	51.8	145	a
Vance	01/11/00	12:20	2000029613	20	13		13		8		1	U									13.1		89%	11			
Vance	01/24/00	12:30	2000049606						1		1	U			6.1		to	51.0		co					51.0	208	a
Swift	09/13/99	16:45	1999379618		2.0		1.8	U	3		1	U	72.7		9.0		to	68.7		co	11.4		99%		72.7	7.3	m
Swift	10/12/99	12:30	1999419618		7.8		7.8		1	U	1	U	73.4		8.4		to	68.0		co	11.8		100%		73.4	4.2	m
Swift	11/08/99	11:40													8.6		to	69.0		co					69.0	6.0	o
Swift	11/15/99	13:10	1999469618		23		23		2		1	U			8.4		to	69.1		co	11.1		95%		69.1	3.8	m
Swift	11/29/99	12:15													7.8		to	69.3		co					69.3	6.0	o
Swift	12/13/99	13:35	1999509618		1.8		1.8	U	4		1		75.2		7.6		to	70.1		co	11.5		96%		75.2	6.0	o
Swift	12/27/99	14:35													7.7		to	69.1		co					69.1	6.0	o
Swift	01/11/00	14:35	2000029618		1.8		1.8	U	1	U	1	U	72.9		7.2		to	68.3		co	11.4		95%		72.9	6.0	o
Swift	01/24/00	12:45													7.8		to	68.8		co					68.8	6.0	o
Hunter	01/12/99	11:30	1999028137		14		14				3		86.0		9.2		th	80.3		ch					86.0	162	o
Hunter	02/16/99	11:35	1999079605		23		23		33		5		83.1		8.6		th	80.9		ch	9.6		82%		83.1	186	r
Hunter	03/15/99	12:17	1999119605		2.0		2.0		2		3		82.1		7.5		th	74.0		ch					82.1	208	r
Hunter	04/12/99	12:18	1999159605		1.8	U	1.8	U	1		2		81.7		8.9		th	62.0		ch	10.4		90%		81.7	139	r
Hunter	05/10/99	11:50	1999199605		2.0		2.0		8		1		80.3		8.7		to	77.0		co	10.8		93%		80.3	139	r
Hunter	06/14/99	11:03	1999249605	7	17		17		11		2		78.5		9.1		th	66.6		ch				1	78.5	148	r
Hunter	06/14/99	11:03	1999249612	7	4.5		4.5		16		2		79.4											1	79.4		
Hunter	07/12/99	11:17	1999289605		79		79		47		2		79.1		9.1		th	64.4		ch					79.1	129	r
Hunter	08/09/99	12:00	1999329605		33		33		15		1	U	79.9		10.8		ta				10.6		96%		79.9	116	a
Hunter	09/13/99	13:20	1999379605		79		79		38		1	U			9.3		to	75.1		co	10.2		89%		75.1	109	a
Hunter	10/12/99	12:05	1999419605		13		7.8		13		1	U			8.8		to	76.0		co	9.6		83%		76.0	115	a

Appendix C2. Skokomish TMDL Water Quality Data.

Staname1	Date	Time	10dlabID	field rep pair L	FCmpn	qual FCmpn	Ecoli	qual Ecoli	FCmf	qual FCmf	TSS	qual TSS	condL	qual condL	temp	qual temp	temp inst	condF	qual condF	cond inst	DO	qual DO	DO %sat	fieldrep pair F	CondC	Qfinal	Qual Qfinal
Hunter	11/08/99	11:00	1999459605	15					26		1				9.0		to	75.0		co					75.0	179	a
Hunter	11/08/99	11:00	1999459613	15					23		2																
Hunter	11/15/99	11:50	1999469605		33		33		27		2				9.0		to	75.3		co	7.8		68%		75.3	194	a
Hunter	11/29/99	11:50	1999489605						12		1	U			8.7		to	76.8		co					76.8	188	a
Hunter	12/13/99	11:15	1999509605		33		33		15		1	U			8.2		to	74.7		co	9.6		81%		74.7	245	a
Hunter	12/27/99	14:00	1999529605						9		3				8.8		to	77.7		co					77.7	156	a
Hunter	01/11/00	12:00	2000029605		33		17		33	J	2				8.1		to	78.4		co	9.0		76%		78.4	160	a
Hunter	01/24/00	11:40	2000049605						9		2				8.5		to	78.6		co					78.6	166	a
UpPurdy	01/13/99	9:31	1999028134		1.8		1.8				7		66.2		7.5		th	54.4		ch					66.2	52.0	o
UpPurdy	02/16/99	16:15	1999079611	1	6.8		4.5		6		3		56.8		7.4		th	56.2		ch	11.7		97%	14	56.8	59.7	o
UpPurdy	02/16/99	16:30	1999079612	1	1.8		1.8		4		3		56.7								11.8		81%	14	56.7		
UpPurdy	03/15/99	17:05	1999119611	3	4.5		4.5		5		4		60.7		8.0		th	54.3		ch				9	60.7	62.9	a
UpPurdy	03/15/99	17:05	1999119613	3	2.0		2.0		1	U	4		60.7											9	60.7		
UpPurdy	05/10/99	17:05	1999199611	6	1.8	U	1.8	U	1	U	2		61.3		10.4		to	70.9		co	10.9		97%	10	61.3	42.5	a
UpPurdy	05/10/99	17:10	1999199614	6	1.8	U	1.8	U	1		2		71.7		10.4		to	71.6		co	11.0		98%	10	71.7		
UpPurdy	06/14/99	17:30	1999249611		11		11		1		2		74.6		13.1		th	62.5		ch					74.6	34.4	a
UpPurdy	07/12/99	19:08	1999289611		7.8		7.8		10		2		77.5		12.4		th				10.4		97%		77.5	28.4	a
UpPurdy	08/09/99	8:10	1999329611		13		13		17		1	U	77.7		10.4		ta				11.0		99%		77.7	24.9	a
UpPurdy	09/13/99	18:05	1999379611		49		49		18		1				11.2		to	72.7		co	10.7		97%		72.7	21.7	a
UpPurdy	10/12/99	13:30	1999419611		1.8		1.8	U	2		1				9.2		to	73.0		co	11.4		99%		73.0	20.1	a
UpPurdy	11/08/99	15:45													9.1		to	71.5		co					71.5	19.7	a
UpPurdy	11/15/99	8:35	1999469611		2.0		2.0		12		3				9.0		to	69.0		co					69.0	21.4	a
UpPurdy	11/29/99	12:50													7.4		to	59.9		co					59.9	20.9	a
UpPurdy	12/13/99	8:25	1999509611		17		17		7		3				6.7		to	54.4		co					54.4	44.3	a
UpPurdy	12/27/99	15:35													7.1		to	58.4		co					58.4	37.5	a
UpPurdy	01/11/00	7:15	2000029611		2.0		2.0		4	J	1				5.9		to	58.8		co					58.8	37.0	a
UpPurdy	01/24/00	14:15													7.1		to	59.1		co					59.1	52.8	a
TenAcre	01/12/99	11:00	1999028133		23		23				1		84.8		8.6		th	79.9		ch					84.8	7.8	o
TenAcre	02/16/99	10:57	1999079603		130		130		130		9		78.9		7.6		th	77.4		ch	8.3		69%		78.9	7.8	o
TenAcre	03/15/99	11:00	1999119603		23		23		3		2		80.2		8.3		th	72.8		ch	8.0		68%		80.2	7.8	o
TenAcre	04/12/99	11:30	1999159603		2.0		2.0		7		3		79.2		8.8		th	74.0		ch	8.1		70%		79.2	7.8	o
TenAcre	05/10/99	11:00	1999199603		49		49		33		1	U	79.2		8.5		to	75.2		co	8.7		74%		79.2	7.8	o
TenAcre	06/14/99	10:30	1999249603		17		6.8		13		1		78.4		9.1		th	64.7		ch	8.0		69%		78.4	7.8	o
TenAcre	07/12/99	10:35	1999289603		130		27		28		1	U	78.6		9.0		th	64.8		ch	7.5		65%		78.6	7.8	o
TenAcre	08/09/99	11:15	1999329603	13	17		17		12		1	U	79.6		9.8		ta				7.4		65%	8	79.6	7.8	o
TenAcre	08/09/99	11:15	1999329613	13	7.8		7.8		9		1	U	79.6								7.3			8	79.6		
TenAcre	09/13/99	12:15	1999379603		4.5		4.5		9		1	U			9.4		to	75.0		co	7.3		63%		75.0	7.8	o

Appendix C2. Skokomish TMDL Water Quality Data.

Staname1	Date	Time	10dlabID	field rep pair L	FCmpn	qual FCmpn	Ecoli	qual Ecoli	FCmf	qual FCmf	TSS	qual TSS	condL	qual condL	temp	qual temp	temp inst	condF	qual condF	cond inst	DO	qual DO	DO %sat	fieldrep pair F	CondC	Qfinal	Qual Qfinal
TenAcre	10/12/99	11:20	1999419603		33		33		30		1	U			9.3		to	75.0		co	7.9		69%		75.0	7.8	o
TenAcre	11/08/99	10:45													9.3		to	83.2		co					83.2	7.8	o
TenAcre	11/15/99	11:10	1999469603		33		33		49		49				9.1		to	78.4		co	6.1		53%		78.4	7.8	o
TenAcre	11/29/99	11:15													8.6		to	77.0		co					77.0	7.8	o
TenAcre	12/13/99	10:30	1999509603		79		79		100		2				6.8		to	77.8		co	8.7		72%		77.8	7.8	o
TenAcre	12/27/99	13:45													8.5		to	75.7		co					75.7	7.8	o
TenAcre	01/11/00	11:25	2000029603		49		49		80		2				7.6		to	74.3		co	8.1		68%		74.3	7.8	o
TenAcre	01/24/00	11:05													8.2		to	75.1		co					75.1	7.8	o
Weaver	01/12/99	11:17	1999028136		13		13				5		80.9		8.5		th	75.7		ch					80.9	51.4	o
Weaver	02/16/99	11:10	1999079604		1100		1100		1900	J	8		80.8		8.1		th	79.2		ch	8.7		74%		80.8	47.0	r
Weaver	03/15/99	11:20	1999119604		2.0		2.0		11		4		78.9		8.3		th	70.2		ch	9.1		77%		78.9	50.8	r
Weaver	04/12/99	12:03	1999159604		4.5		4.5		8		5		76.3		9.0		th	70.0		ch	9.7		84%		76.3	44.1	r
Weaver	05/10/99	11:25	1999199604	4	17		17		11		3		75.9		9.0		to	72.0		co	10.2		88%	12	75.9	39.6	r
Weaver	05/10/99	11:30	1999199612	4	23		23		11		3		75.5		9.0		to	75.4		co	10.3		89%	12	75.5		
Weaver	06/14/99	10:47	1999249604		49		49		31		2		74.6		9.6		th	61.6		ch					74.6	41.5	r
Weaver	07/12/99	10:49	1999289604	10	110		110		71		3		75.4		9.7		th	59.7		ch	9.4		83%	13	75.4	38.1	o
Weaver	07/12/99	10:49	1999289612	10	95		95		33		2		75.6								9.4			13	75.6		
Weaver	08/09/99	11:40	1999329604		33		33		23		1		74.8		11.2		ta				9.9		90%		74.8	35.9	r
Weaver	09/13/99	12:40	1999379604		170		170		69		1				9.9		to	69.9		co	10.0		88%		69.9	40.0	r
Weaver	10/12/99	11:35	1999419604		7.8		7.8		19		1				8.9		to	71.0		co	9.9		86%		71.0	45.2	r
Weaver	11/08/99	10:50													8.9		to	74.2		co					74.2	64.5	r
Weaver	11/15/99	11:25	1999469604		33		33		39		7				9.0		to	73.1		co					73.1	57.8	r
Weaver	11/29/99	11:20													8.4		to	73.8		co					73.8	55.2	r
Weaver	12/13/99	10:45	1999509604		64		64		34		3				7.4		to	73.7		co					73.7	72.7	r
Weaver	12/27/99	13:50													8.5		to	73.3		co					73.3	44.1	r
Weaver	01/11/00	11:40	2000029604		49		49		61		3				7.7		to	73.3		co					73.3	46.7	r
Weaver	01/24/00	11:15													8.3		to	73.3		co					73.3	48.9	r
WeavrLow	09/13/99	13:00	1999379617		79		79		50		1	U			9.8		to	68.8		co	10.0		88%		68.8	38.8	r
WeavrLow	10/12/99	11:45	1999419617		13		13		19		1	U			8.9		to	70.0		co	9.7		84%		70.0	44.1	r
WeavrLow	11/08/99	10:35	1999459617						190	J	2				8.8		to	72.8		co					72.8	57.9	r
WeavrLow	11/15/99	11:35	1999469617		33		17		8		5		76.4		8.8		to	71.3		co	7.8		67%		76.4	58.5	r
WeavrLow	11/29/99	11:30	1999489617	17					10		1				8.3		to	72.4		co					72.4	54.6	r
WeavrLow	11/29/99	11:30	1999489613	17					3		1																
WeavrLow	12/13/99	10:55	1999509617		110		110		49		3				7.2		to	72.2		co	9.8		81%		72.2	84.1	a
WeavrLow	12/27/99	12:45	1999529617						8		2				8.3		to	72.4		co					72.4	50.9	a
WeavrLow	01/11/00	11:45	2000029617		49		49		23		2				7.3		to	72.5		co	9.0		75%		72.5	45.1	a
WeavrLow	01/24/00	11:25	2000049617	21					18		2				8.1		to	72.6		co					72.6	45.6	a

Appendix C2. Skokomish TMDL Water Quality Data.

Staname1	Date	Time	10dlabID	field rep pair L	FCmpn	qual FCmpn	Ecoli	qual Ecoli	FCmf	qual FCmf	TSS	qual TSS	condL	qual condL	temp	qual temp	temp inst	condF	qual condF	cond inst	DO	qual DO	DO %sat	fieldrep pair F	CondC	Qfinal	Qual Qfinal
WeavrLow	01/24/00	11:25	2000049613	21					16		2																
PurBour	01/12/99	10:30	1999028132		33		33				6		77.9		7.8		th	73.8		ch					77.9	144	i
PurBour	02/16/99	10:35	1999079602		79		79		110		3		73.7		7.1		th	72.9		ch	9.5		78%		73.7	149	i
PurBour	03/15/99	10:41	1999119602		22		11		10		1	U	72.3		7.6		th	64.2		ch					72.3	158	i
PurBour	04/12/99	11:03	1999159602		13		13		2		1	U	75.1		8.7		th	65.0		ch	10.0		86%		75.1	135	i
PurBour	05/10/99	10:30	1999199602		17		17		22		2		76.5		7.9		to	73.7		co	10.6		89%		76.5	118	i
PurBour	06/14/99	10:10	1999249602		33		33		15		2		77.4		10.2		th	64.3		ch	8.8		78%		77.4	110	i
PurBour	07/12/99	10:09	1999289602		130		130		43		1	U	79.0		10.7		th	62.8		ch					79.0	97.2	i
PurBour	08/09/99	10:55	1999329602		33		33		35		1	U	78.2		11.2		ta				9.1		83%		78.2	89.5	i
PurBour	09/13/99	11:35	1999379602		33		33		43		1				9.9		to	74.1		co	8.9		78%		74.1	87.2	i
PurBour	10/12/99	11:10	1999419602		49		49		14		1	U			9.1		to	76.0		co	8.8		76%		76.0	92.2	i
PurBour	11/08/99	10:15	1999459602						59		1				9.0		to	74.7		co					74.7	110	i
PurBour	11/15/99	10:45	1999469602	16	49		33		25	J	1				9.1		to	74.5		co	7.0		61%	4	74.5	113	i
PurBour	11/15/99	11:00	1999469613	16	33		33		25		1				9.1		to	74.7		co	7.0		60%	4	74.7		
PurBour	11/29/99	11:05	1999489602						10		1	U			7.6		to	72.6		co					72.6	107	i
PurBour	12/13/99	10:15	1999509602		240		240		250	J	5				5.9		to	57.4		co	9.9		79%		57.4	178	i
PurBour	12/27/99	11:05	1999529602	19					36		1				6.7		to	72.8		co					72.8	124	i
PurBour	12/27/99	11:05	1999529613	19					20		1																
PurBour	01/11/00	11:15	2000029602		170		170		44		1				5.2		to	72.0		co	9.6		75%		72.0	116	i
PurBour	01/24/00	10:55	2000049602						13		1	U			6.6		to	71.1		co					71.1	137	i
Ikes	09/13/99	11:13	1999379616		23		23		55		2		115		12.4		to	109		co	7.3		68%		115	1.4	m
Ikes	10/12/99	10:30	1999419616		49		49		26		3		94.5		9.9		to	90.0		co	7.9		70%		94.5	4.4	m
Ikes	11/08/99	9:55													8.8		to	54.2		co					54.2	73.6	r
Ikes	11/15/99	10:05	1999469616		33		33		13		6		58.9		8.8		to	54.7		co	9.9		85%		58.9	84.1	m
Ikes	11/29/99	10:00													6.9		to	53.5		co					53.5	87.2	m
Ikes	12/13/99	9:40	1999509616		33		33		33		13				5.7		to	43.9		co	11.9		95%		43.9	176	r
Ikes	12/27/99	10:30													5.4		to	59.7		co					59.7	48.2	r
Ikes	01/11/00	10:50	2000029616		6.8		6.8		12		1				4.4		to	57.3		co	12.5		96%		57.3	52.5	r
Ikes	01/24/00	10:15													4.9		to	55.6		co					55.6	59.9	r
Rods	10/12/99	10:55	1999419619		7.8		7.8		15		2				9.6		to	112		co					112	6.5	m
Rods	11/08/99	10:00													8.8		to	59.4		co					59.4	59.1	r
Rods	11/15/99	10:25	1999469619		17		17		20		4				9.1		to	59.4		co	9.0		78%		59.4	75.4	m
Rods	11/29/99	10:30													6.5		to	58.5		co					58.5	87.9	r
Rods	12/13/99	10:00	1999509619		22		22		12		6		46.3		5.4		to	43.1		co	11.3		89%		46.3	158	r
Rods	12/27/99	10:40													4.9		to	68.9		co	12.0		94%		68.9	17.4	m
Rods	01/11/00	11:00	2000029619		78		78	J	11		1	U	74.7		3.0		to	72.5		co	11.3		84%		74.7	23.9	r
Rods	01/24/00	10:25																								30.0	r

Appendix C2. Skokomish TMDL Water Quality Data.

Staname1	Date	Time	10dlabID	field rep pair L	FCmpn	qual FCmpn	Ecoli	qual Ecoli	FCmf	qual FCmf	TSS	qual TSS	condL	qual condL	temp	qual temp	temp inst	condF	qual condF	cond inst	DO	qual DO	DO %sat	fieldrep pair F	CondC	Qfinal	Qual Qfinal
NoName1	09/13/99	10:30	1999379615		46		46		28		2				9.5		to	149		co	8.8		77%		149	2.3	m
NoName1	10/12/99	10:10	1999419615		33		17		22		1				9.3		to	152		co	8.9		78%		152	2.5	m
NoName1	11/08/99	9:40													9.1		to	152		co					152	2.4	o
NoName1	11/15/99	9:45	1999469615		33		23		29		3				9.3		to	148		co	4.9		43%		148	2.4	o
NoName1	11/29/99	9:50													7.4		to	104		co					104	2.4	o
NoName1	12/27/99	10:20													7.0		to	143		co					143	2.4	o
NoName1	01/11/00	10:30	2000029615		4.5		4.5		4		3				6.2		to	138		co	8.6		70%		138	2.4	o
NoName1	01/24/00	10:30													6.8		to	140		co					140	2.4	o

Appendix C3. Skokomish Tribe FCmpn data for TMDL study period.						
Staname1$	Date	FCmpn (#/100mL)		Staname1$	Date	FCmpn (#/100mL)
SkokChic	01/12/99	15		Hunter	08/09/99	15
SkokChic	02/16/99	25		Hunter	09/13/99	30
SkokChic	03/15/99	5		Hunter	10/12/99	10
SkokChic	04/12/99	10		Hunter	11/15/99	30
SkokChic	05/10/99	35		Hunter	12/13/99	10
SkokChic	06/14/99	5		Hunter	01/11/00	50
SkokChic	07/12/99	20		TenAcre	01/12/99	15
SkokChic	08/09/99	33		TenAcre	02/16/99	70
SkokChic	09/13/99	40		TenAcre	03/15/99	5
SkokChic	10/12/99	30		TenAcre	04/12/99	5
SkokChic	11/15/99	10		TenAcre	05/10/99	20
SkokChic	12/13/99	10		TenAcre	06/14/99	35
SkokChic	01/11/00	5		TenAcre	07/12/99	20
Skok106b	01/12/99	10		TenAcre	08/09/99	20
Skok106b	02/16/99	30		TenAcre	09/13/99	15
Skok106b	03/15/99	40		TenAcre	10/12/99	30
Skok106b	04/12/99	20		TenAcre	11/15/99	75
Skok106b	05/10/99	20		TenAcre	12/13/99	90
Skok106b	06/14/99	20		TenAcre	01/11/00	125
Skok106b	07/12/99	35		Weaver	01/12/99	45
Skok106b	08/09/99	50		Weaver	02/16/99	240
Skok106b	09/13/99	150		Weaver	03/15/99	10
Skok106b	10/12/99	45		Weaver	04/12/99	15
Skok106b	11/15/99	20		Weaver	05/10/99	5
Skok106b	12/13/99	65		Weaver	06/14/99	33
Skok106b	01/11/00	10		Weaver	07/12/99	45
Vance	01/12/99	5		Weaver	08/09/99	25
Vance	02/16/99	5		Weaver	09/13/99	85
Vance	03/15/99			Weaver	10/12/99	25
Vance	04/12/99	5		Weaver	11/15/99	70
Vance	05/10/99	5		Weaver	12/13/99	30
Vance	06/14/99	5		Weaver	01/11/00	50
Vance	07/12/99	10		PurBour	01/12/99	33
Vance	08/09/99	45		PurBour	02/16/99	500
Vance	09/13/99	25		PurBour	03/15/99	10
Vance	10/12/99	15		PurBour	04/12/99	15
Vance	11/15/99	5		PurBour	05/10/99	20
Vance	12/13/99	10		PurBour	06/14/99	50
Vance	01/11/00	25		PurBour	07/12/99	25
Hunter	01/12/99	5		PurBour	08/09/99	35
Hunter	02/16/99	15		PurBour	09/13/99	30
Hunter	03/15/99			PurBour	10/12/99	20
Hunter	04/12/99	5		PurBour	11/15/99	30
Hunter	05/10/99	5		PurBour	12/13/99	110
Hunter	06/14/99	5		PurBour	01/11/00	45
Hunter	07/12/99	75				

Appendix D. FC Load Allocation Scenarios.

Five FC load allocation scenarios were examined to determine how and if target reductions in FC values could be met. Target FC loads were derived for the sites Skok106 and PurBour based on target FC GMVs (Table 6) and the mean daily flow. FC and flow values from the 10-month averaging period were used for these scenarios. Mass balance calculations were used to predict FC loads from the scenarios and compare these loads to target loads. Various FC values were assigned to sites in order to examine their effects on target loads at downstream sites. Loading analyses consisted of summing upstream loads at key sites and comparing these summed loads to target loads. The five scenarios examined are summarized below and in Table D1.

1. Sites where the 1999-2000 study FC values did not meet standards had their FC values reduced to meet the rollback targets (as in Table 6). Sites that met water quality standards were given the same FC values as those found during the study. The residual loads for sites Skok101, PurBour, and Skok106 were set at values found in the 1999-2000 study.

2. Sites where study FC values did not meet the standards had their FC values reduced to meet the rollback targets. Sites that met standards were given rollback factors that resulted in the site meeting the water quality standards for the GMV and 90th percentile. Sites SFSkok and NFSkok were assigned FC levels twice that found during the study. (The FC values found at these sites are expected to remain relatively low in the future because of their forested nature and lack of residential or agricultural land use in these basins). The residual loads for sites Skok101, PurBour, and Skok106 were set at half the values found during the study (a rollback factor of 0.5).

3. Sites where study FC values did not meet the standards had their FC values reduced to meet the target values. Sites that met standards were given rollback factors that were half of the increase in rollback factors in Scenario 2. (The resulting FC values were then between the study values and the standards). Sites SFSkok and NFSkok were assigned FC levels twice that found during the study. The residual loads for sites Skok101, PurBour, and Skok106 were reduced until site Skok106 met the rollback target; this resulted in a rollback factor of 0.28, which represents a 72% reduction in each residual.

4. Sites where study FC values did not meet the standards had their FC values reduced an additional 10% of that needed to meet the rollback targets. Sites that met standards were reduced further than in Scenario 3, to one-quarter of the increase used to attain the rollback factors in Scenario 2. Sites SFSkok and NFSkok were assigned FC levels twice that found during the study. The residual loads for sites Skok101, PurBour, and Skok106 were given a rollback factor of 0.28, as in scenario 3.

5. Sites where study FC values did not meet the standards had their FC values reduced an additional 10% of that needed to meet the rollback targets. Sites that met standards, including SFSkok and NFSkok, were set at study values (rollback factor of 1.00). The residual loads for sites Skok101, PurBour, and Skok106 were given a rollback factor of 0.28, as in scenarios 3 and 4.

The results of the five load balance scenarios summarized in Table D1 are described below. Tables D2-D6 show results of mass balance calculations for each scenario and displays resultant FC values, loads, and percent reductions for each site. Table D7 shows the final recommended allocation, where most FC levels were set equal to those found during the study and others set at target levels. Lower mainstem corridor loads were reduced so that site Skok106 met its target.

- Scenario 1 results in the Skok106 load being 160% greater than the target value. The residual load at Skok106 accounts for 58% of the total load at Skok106 and is likely the main reason that this scenario does not protect marine water quality standards.
- Scenario 2 is not protective of Skok106 target values as it is 133% of the target load. This scenario results in a load increase of 26% at Skok101, and load decreases at PurBour and Skok106 of 52% and 25%, respectively. Again, loading due to the residual load at Skok106 accounts for a large portion, about 35%, of the load in this scenario. This scenario demonstrates that meeting Class AA standards for FC at upstream sites is not adequate to protect the marine waters.
- Scenario 3 yields loads that result in Skok106 meeting its target value. Many sites had FC GMVs set at a value between those found in the study results and the water quality standard. This scenario results in an 11% increase at Skok101, and a 60% decrease at PurBour. Skok106 values are reduced 44% thus allowing the target FC GMV of 18.5, and the target 90^{th} percentile of 67.7, to be met. Scenario 3 could have many variations since the loads from many sites could be adjusted in order for the target values at key downstream sites to be met. If some sites are allowed a larger load, then a corresponding decrease would be needed at other sites.
- Scenario 4 has all sites meeting their target values or water quality standards and yields a load that results in Skok106 meeting its target value. Loads at all sites were reduced further than they were in Scenario 3. This scenario results in reductions of 70% and 48% at PurBour and Skok106, and an increase of 7% at Skok101. As in Scenario 3, many variations of this scenario would allow Skok106 to meet its target. This scenario may represent conditions after all sources of FC pollution are effectively managed. This scenario yields a load at Skok106 that is 93% of the target load.
- Scenario 5 may represent the most protective outcome of FC pollution management in the Skokomish basin with FC levels at 78% of study levels. All sites meet targets and reductions of 21%, 73%, and 56% result at Skok101, PurBour, and Skok106, respectively. As in Scenarios 3 and 4, many variations of this scenario would allow Skok106 to meet its targets.

Every scenario that results in key sites meeting target levels requires that sources of FC pollution be found and managed. The location and magnitude of potential FC reductions can be better evaluated after closer examination of land uses and management practices. Such an examination was beyond the scope of this study. Potential contributions of wildlife should also be considered as land uses are considered. A load allocation was not assigned to wildlife because quantitative information about all potential FC sources was lacking. The contribution of wildlife to FC loads would be considered a natural background level and given a load allocation. This would result in smaller load allocations to human-related FC sources (e.g. septic systems, livestock management) and require that greater reductions be achieved where the sources are manageable.

Table D1. Summary of rollback factors used in different load allocation scenarios with results compared to target loads at Skok106.

Load Allocation Scenario	Factor for streams that did not meet standards during the study	Factor for streams that did meet standards during the study	Factor for the residuals at 3 key sites	Factor for sites SFSkok and NFSkok	Does scenario meet target load at Skok106?	Scenario result as percent of target load at Skok106	Resulting GMV and 90%ile at Skok101	Resulting GMV and 90%ile at PurBour	Resulting GMV and 90%ile at Skok106
1	factor reduced to meet target (0.318-1.000)	factor at study level (1.00)	1.00	1.00	NO	161%	11.6 30.8	25.7 69.5	29.7 108.7
2	factor reduced to meet target (0.318-0.751)	factor yields value equal to the water quality standard (1.259-6.585)	0.50	2.00	NO	133%	14.6 38.8	26.2 70.7	24.5 90.0
3	factor reduced to meet target (0.318-0.751)	factor is one-half of the increase used in scenario 2 (1.067-3.793)	0.28	2.00	YES	100%	12.9 34.3	21.7 58.5	18.5 67.7
4	factor reduced 10% more than needed to meet target (0.218-0.651)	factor is one-quarter of the increase used in scenario 2 (1.034-2.396)	0.28	2.00	YES	93%	12.4 33.1	16.1 43.4	17.2 63.0
5	factor reduced 10% more than needed to meet target (0.218-0.651)	factor at study level (1.00)	0.28	1.00	YES	78%	9.2 24.4	14.8 40.0	14.4 52.9

	Table D2. Skokomish River FC TMDL load allocation scenario.								
	SCENARIO 1								
	Site	**FC rollback factor**	FC calc GMV	FC G90%ile	**FC load (W)**	% of FCW of sub-basin	% of FCW of whole basin	**% change in FCW from study period**	**% change in FC from study period**
Skok101 sub-basin	SFSkok	**1.000**	2.3	4.1	6.61E+10	20%	5.5%	0.0%	0.0%
	Vance	**1.000**	9.7	52.5	3.65E+10	11%	3.0%	0.0%	0.0%
	NFSkok	**1.000**	2.7	5.6	1.38E+10	4.2%	1.1%	0.0%	0.0%
	Swift	**1.000**	5.9	15.2	9.54E+08	0.3%	0.1%	0.0%	0.0%
	Hunter	**1.000**	21.9	88.2	1.18E+11	36%	9.7%	0.0%	0.0%
	Upper mainstem corridor	**1.000**			9.62E+10	29%	8.0%	0.0%	
	Skok101 summed	***1.000***	11.6	30.8	**3.31E+11**	100%	27%	**0.0%**	
	residual/Skok101summed				29%				
PurBour sub-basin	Weaver	**0.318**	17.5	100.0	**5.86E+10**	51%	4.8%	**-68.2%**	**-68.2%**
	TenAcre	**0.751**	25.6	100.0	**8.23E+09**	7.1%	0.7%	**-24.9%**	**-24.9%**
	UpPurdy	**1.000**	5.8	25.7	7.80E+09	6.8%	0.6%	0.0%	0.0%
	Upper Purdy corridor	**1.000**			4.09E+10	35%	3.4%	0.0%	
	PurBour summed	***0.474***	25.7	69.5	**1.16E+11**	100%	10%	**-52.6%**	
	residual/PurBour summed				35%				
			PurBour target FCW:		1.66E+11				
			Scenario FCW as % of target FCW:		**69%**				
Skok106 sub-basin	Skok101 summed	***1.000***	11.6	30.8	3.31E+11	27%	27%	0.0%	
	PurBour summed	***0.474***	25.7	69.5	1.16E+11	10%	10%	-52.6%	
	Ikes	**1.000**	28.5	42.6	3.78E+10	3.1%	3.1%	0.0%	0.0%
	Rods	**1.000**	25.8	49.2	2.42E+10	2.0%	2.0%	0.0%	0.0%
	NoName1	**1.000**	28.5	44.6	1.75E+09	0.1%	0.1%	0.0%	0.0%
	Lower mainstem corridor	**1.000**			6.99E+11	58%	58%	0.0%	
	Skok106 summed	***0.904***	29.7	108.7	**1.21E+12**	100%	100%	**-9.6%**	
	residual/Skok106 summed				58%				
			Skok106 target FCW:		7.53E+11				
			Scenario FCW as % of target FCW:		**161%**				
	Notes:								
	* Underlined values backcalculated from load and flow (different estimate than others)								
	* *Factors in italics are the resulting factors when backcalculated from reductions in summed values (rather than a given target reduction factor)*								
	* "residual" refers to the input from the corridor upstream of the site								

Table D3. Skokomish River FC TMDL load allocation scenario.

SCENARIO 2

	Site	FC rollback factor	FC calc GMV	FC G90%ile	FC load (W)	% of FCW of sub-basin	% of FCW of whole basin	% change in FCW from study period	% change in FC from study period
Skok101 sub-basin	SFSkok	**2.000**	4.6	8.2	1.32E+11	32%	13%	100.0%	100.0%
	Vance	**1.904**	18.5	100.0	6.95E+10	17%	6.9%	90.4%	90.4%
	NFSkok	**2.000**	5.5	11.1	2.76E+10	6.6%	2.8%	100.0%	100.0%
	Swift	**6.585**	38.6	100.0	6.28E+09	1.5%	0.6%	558.5%	558.5%
	Hunter	**1.134**	24.8	100.0	1.34E+11	32%	13%	13.4%	13.4%
	Upper mainstem corridor	**0.500**			4.81E+10	12%	4.8%	-50.0%	
	Skok101 summed	***1.259***	14.6	38.8	**4.17E+11**	100%	42%	**25.9%**	
	residual/Skok101summed				12%				
PurBour sub-basin	Weaver	**0.318**	17.5	100.0	**5.86E+10**	50%	5.9%	**-68.2%**	**-68.2%**
	TenAcre	**0.751**	25.6	100.0	**8.23E+09**	7.0%	0.8%	**-24.9%**	**-24.9%**
	UpPurdy	**3.900**	22.5	100.0	3.04E+10	26%	3.0%	290.0%	290.0%
	Upper Purdy corridor	**0.500**			2.04E+10	17%	2.0%	-50.0%	
	PurBour summed	***0.483***	26.2	70.7	**1.18E+11**	100%	12%	**-51.7%**	
	residual/PurBour summed				17%				
		PurBour target FCW:			1.66E+11				
	Scenario FCW as % of target FCW:				**71%**				
Skok106 sub-basin	Skok101 summed	***1.259***	14.6	38.8	4.17E+11	42%	42%	25.9%	
	PurBour summed	***0.483***	26.2	70.7	1.18E+11	12%	12%	-51.7%	
	Ikes	**1.755**	50.0	74.7	6.64E+10	6.6%	6.6%	75.5%	75.5%
	Rods	**1.935**	50.0	95.1	4.69E+10	4.7%	4.7%	93.5%	93.5%
	NoName1	**1.755**	50.0	78.3	3.07E+09	0.3%	0.3%	75.5%	75.5%
	Lower mainstem corridor	**0.500**			3.49E+11	35%	35%	-50.0%	
	Skok106 summed	***0.748***	24.5	90.0	**1.00E+12**	100%	100%	**-25.2%**	
	residual/Skok106 summed				35%				
		Skok106 target FCW:			7.53E+11				
	Scenario FCW as % of target FCW:				**133%**				

Notes:

* Underlined values backcalculated from load and flow (different estimate than others)

* *Factors in italics are the resulting factors when backcalculated from reductions in summed values (rather than a given target reduction factor)*

* "residual" refers to the input from the corridor upstream of the site

	Table D4. Skokomish River FC TMDL load allocation scenario.								
	SCENARIO 3								
	Site	**FC rollback factor**	FC calc GMV	FC G90%ile	**FC load (W)**	% of FCW of sub-basin	% of FCW of whole basin	**% change in FCW from study period**	**% change in FC from study period**
Skok101 sub-basin	SFSkok	**2.000**	4.6	8.2	1.32E+11	36%	18%	100.0%	100.0%
	Vance	**1.452**	14.1	76.3	5.30E+10	14%	7.0%	45.2%	45.2%
	NFSkok	**2.000**	5.5	11.1	2.76E+10	7.5%	3.7%	100.0%	100.0%
	Swift	**3.793**	22.2	57.6	3.62E+09	1.0%	0.5%	279.3%	279.3%
	Hunter	**1.067**	23.4	94.1	1.26E+11	34%	17%	6.7%	6.7%
	Upper mainstem corridor	**0.280**			2.69E+10	7%	3.6%	-72.0%	
	Skok101 summed	***1.114***	12.9	34.3	**3.69E+11**	100%	49%	**11.4%**	
	residual/Skok101summed				7%				
PurBour sub-basin	Weaver	**0.318**	17.5	100.0	**5.86E+10**	60%	7.8%	**-68.2%**	**-68.2%**
	TenAcre	**0.751**	25.6	100.0	**8.23E+09**	8.5%	1.1%	**-24.9%**	**-24.9%**
	UpPurdy	**2.450**	14.1	62.8	1.91E+10	19.6%	2.5%	145.0%	145.0%
	Upper Purdy corridor	**0.280**			1.14E+10	12%	1.5%	-72.0%	
	PurBour summed	***0.399***	21.7	58.5	**9.74E+10**	100%	12.9%	**-60.1%**	
	residual/PurBour summed				12%				
				PurBour target FCW:	1.66E+11				
				Scenario FCW as % of target FCW:	**59%**				
Skok106 sub-basin	Skok101 summed	***1.114***	12.9	34.3	3.69E+11	49%	49%	11.4%	
	PurBour summed	***0.399***	21.7	58.5	9.74E+10	13%	13%	-60.1%	
	Ikes	**1.378**	39.2	58.6	5.21E+10	6.9%	6.9%	37.8%	37.8%
	Rods	**1.468**	37.9	72.2	3.56E+10	4.7%	4.7%	46.8%	46.8%
	NoName1	**1.378**	39.2	61.5	2.41E+09	0.3%	0.3%	37.8%	37.8%
	Lower mainstem corridor	**0.280**			1.96E+11	26%	26%	-72.0%	
	Skok106 summed	***0.562***	18.5	67.7	**7.52E+11**	100%	100%	**-43.8%**	<-Note A
	residual/Skok106 summed				26%				
				Skok106 target FCW:	7.53E+11				
				Scenario FCW as % of target FCW:	**100%**				
	Notes:								
	* Underlined values backcalculated from load and flow (different estimate than others)								
	target reduction factor)								
	* "residual" refers to the input from the corridor upstream of the site								
	A. 0.01 percent subtracted from original value to correct for rounding errors for display of GMV and 90%ile								

	Table D5. Skokomish River FC TMDL load allocation scenario.								
	SCENARIO 4								
	Site	**FC rollback factor**	FC calc GMV	FC G90%ile	**FC load (W)**	% of FCW of sub-basin	% of FCW of whole basin	**% change in FCW from study period**	**% change in FC from study period**
Skok101 sub-basin	SFSkok	**2.000**	4.6	8.2	1.32E+11	37%	19%	100.0%	100.0%
	Vance	**1.226**	11.9	64.4	4.47E+10	13%	6.4%	22.6%	22.6%
	NFSkok	**2.000**	5.5	11.1	2.76E+10	7.8%	3.9%	100.0%	100.0%
	Swift	**2.396**	14.0	36.4	2.29E+09	0.6%	0.3%	139.6%	139.6%
	Hunter	**1.034**	22.6	91.1	1.22E+11	34%	17%	3.4%	3.4%
	Upper mainstem corridor	**0.280**			2.69E+10	8%	3.8%	-72.0%	
	Skok101 summed	***1.073***	12.4	33.1	**3.56E+11**	100%	51%	**7.3%**	
	residual/Skok101summed				8%				
PurBour sub-basin	Weaver	**0.218**	12.0	68.6	**4.02E+10**	56%	5.7%	**-78.2%**	**-78.2%**
	TenAcre	**0.651**	22.2	86.7	**7.13E+09**	9.9%	1.0%	**-34.9%**	**-34.9%**
	UpPurdy	**1.725**	9.9	44.2	1.35E+10	19%	1.9%	72.5%	72.5%
	Upper Purdy corridor	**0.280**			1.14E+10	16%	1.6%	-72.0%	
	PurBour summed	***0.296***	16.1	43.4	**7.22E+10**	100%	10%	**-70.4%**	
	residual/PurBour summed				16%				
		PurBour target FCW:			1.66E+11				
		Scenario FCW as % of target FCW:			**43%**				
Skok106 sub-basin	Skok101 summed	***1.073***	12.4	33.1	3.56E+11	51%	51%	7.3%	
	PurBour summed	***0.296***	16.1	43.4	7.22E+10	10%	10%	-70.4%	
	Ikes	**1.189**	33.9	50.6	4.50E+10	6.4%	6.4%	18.9%	18.9%
	Rods	**1.234**	31.9	60.7	2.99E+10	4.3%	4.3%	23.4%	23.4%
	NoName1	**1.189**	33.8	53.1	2.08E+09	0.3%	0.3%	18.9%	18.9%
	Lower mainstem corridor	**0.280**			1.96E+11	28%	28%	-72.0%	
	Skok106 summed	***0.524***	17.2	63.0	**7.00E+11**	100%	100%	**-47.6%**	
	residual/Skok106 summed				28%				
		Skok106 target FCW:			7.53E+11				
		Scenario FCW as % of target FCW:			**93%**				
	Notes:								
	* Underlined values backcalculated from load and flow (different estimate than others)								
	** Factors in italics are the resulting factors when backcalculated from reductions in summed values (rather than a given target reduction factor)*								

	Table D6. Skokomish River FC TMDL load allocation scenario.								
	SCENARIO 5								
	Site	**FC rollback factor**	FC calc GMV	FC G90%ile	**FC load (W)**	% of FCW of sub-basin	% of FCW of whole basin	**% change in FCW from study period**	**% change in FC from study period**
Skok101 sub-basin	SFSkok	**1.000**	2.3	4.1	6.61E+10	25%	11%	0.0%	0.0%
	Vance	**1.000**	9.7	52.5	3.65E+10	14%	6.2%	0.0%	0.0%
	NFSkok	**1.000**	2.7	5.6	1.38E+10	5.3%	2.3%	0.0%	0.0%
	Swift	**1.000**	5.9	15.2	9.54E+08	0.4%	0.2%	0.0%	0.0%
	Hunter	**1.000**	21.9	88.2	1.18E+11	45%	20%	0.0%	0.0%
	Upper mainstem corridor	**0.280**			2.69E+10	10%	4.6%	-72.0%	
	Skok101 summed	***0.791***	9.2	24.4	**2.62E+11**	100%	45%	**-20.9%**	
	residual/Skok101summed				10%				
PurBour sub-basin	Weaver	**0.218**	12.0	68.6	**4.02E+10**	60%	6.8%	**-78.2%**	**-78.2%**
	TenAcre	**0.651**	22.2	86.7	**7.13E+09**	11%	1.2%	**-34.9%**	**-34.9%**
	UpPurdy	**1.000**	5.8	25.7	7.80E+09	12%	1.3%	0.0%	0.0%
	Upper Purdy corridor	**0.280**			1.14E+10	17%	1.9%	-72.0%	
	PurBour summed	***0.273***	14.8	40.0	**6.66E+10**	100%	11.3%	**-72.7%**	
	residual/PurBour summed				17%				
				PurBour target FCW:	1.66E+11				
				Scenario FCW as % of target FCW:	**40%**				
Skok106 sub-basin	Skok101 summed	***0.791***	9.2	24.4	2.62E+11	45%	45%	-20.9%	
	PurBour summed	***0.273***	14.8	40.0	6.66E+10	11%	11%	-72.7%	
	Ikes	**1.000**	28.5	42.6	3.78E+10	6.4%	6.4%	0.0%	0.0%
	Rods	**1.000**	25.8	49.2	2.42E+10	4.1%	4.1%	0.0%	0.0%
	NoName1	**1.000**	28.5	44.6	1.75E+09	0.3%	0.3%	0.0%	0.0%
	Lower mainstem corridor	**0.280**			1.96E+11	33%	33%	-72.0%	
	Skok106 summed	***0.440***	14.4	52.9	**5.88E+11**	100%	100%	**-56.0%**	
	residual/Skok106 summed				33%				
				Skok106 target FCW:	7.53E+11				
				Scenario FCW as % of target FCW:	**78%**				
	Notes:								
	* Underlined values backcalculated from load and flow (different estimate than others)								
	* *Factors in italics are the resulting factors when backcalculated from reductions in summed values (rather than a given target reduction factor)*								
	* "residual" refers to the input from the corridor upstream of the site								

Table D7. Skokomish River FC TMDL load allocation scenario.

SCENARIO 6 Final recommended load allocation scenario.

	Site	FC rollback factor	FC calc GMV	FC G90%ile	FC load (W)	% of FCW of sub-basin	% of FCW of whole basin	% change in FCW from study period	% change in FC from study period
Skok101 sub-basin	SFSkok	**1.000**	2.3	4.1	6.61E+10	20%	9%	0.0%	0.0%
	Vance	**1.000**	9.7	52.5	3.65E+10	11%	4.9%	0.0%	0.0%
	NFSkok	**1.000**	2.7	5.6	1.38E+10	4.2%	1.8%	0.0%	0.0%
	Swift	**1.000**	5.9	15.2	9.54E+08	0.3%	0.1%	0.0%	0.0%
	Hunter	**1.000**	21.9	88.2	1.18E+11	36%	16%	0.0%	0.0%
	Upper mainstem corridor	**1.000**			9.62E+10	29%	12.8%	0.0%	
	Skok101 summed	***1.000***	11.6	30.8	**3.31E+11**	100%	44%	**0.0%**	
PurBour sub-basin	Weaver	**0.318**	17.5	100.0	**5.86E+10**	51%	7.8%	**-68.2%**	**-68.2%**
	TenAcre	**0.751**	25.6	100.0	**8.23E+09**	7.1%	1.1%	**-24.9%**	**-24.9%**
	UpPurdy	**1.000**	5.8	25.7	7.80E+09	7%	1.0%	0.0%	0.0%
	Upper Purdy corridor	**1.000**			4.09E+10	35%	5.4%	0.0%	
	PurBour summed	***0.474***	25.7	69.4	**1.16E+11**	100%	15%	**-52.6%**	
		PurBour target FCW:			1.66E+11				
	Scenario FCW as % of target FCW:				**69%**				
Skok106 sub-basin	Skok101 summed	***1.000***	11.6	30.8	3.31E+11	44%	44%	0.0%	
	PurBour summed	***0.474***	25.7	69.4	1.16E+11	15%	15%	-52.6%	
	Ikes	**1.000**	28.5	42.6	3.78E+10	5.0%	5.0%	0.0%	0.0%
	Rods	**1.000**	25.8	49.2	2.42E+10	3.2%	3.2%	0.0%	0.0%
	NoName1	**1.000**	28.5	44.6	1.75E+09	0.2%	0.2%	0.0%	0.0%
	Lower mainstem corridor	**0.345**			2.41E+11	32%	32%	-65.5%	
	Skok106 summed	***0.563***	18.5	67.7	**7.52E+11**	100%	100%	**-43.7%**	<-Note A
		Skok106 target FCW:			7.53E+11				
	Scenario FCW as % of target FCW:				**100%**				
	Notes:								
	* Underlined values backcalculated from load and flow (different estimate than others)								
	target reduction factor)								
	* "residual" refers to the input from the corridor upstream of the site								
	Note A: 0.01 percent subtracted from original value to correct for rounding errors for display of GMV and 90%ile								